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March 24, 2003

TO: Citizens Interested in Proposed Water Quality Standards

FROM: Megan White, P.E., Manager
Water Quality Program

RE: Draft Cost Benefit Analysis

Attached is the DRAFT cost benefit analysis for Washington's proposed changes to the water quality standards. This is a preliminary draft; we are very interested in your feedback on the assumptions and analysis we have used. Please give your feedback to us by April 22, 2003. It is important to note that this analysis is based on the proposed rule we issued for formal public comment on December 19, 2002.

This analysis uses general information to determine the probable costs and probable benefits of the proposed standards over the entire state. It will not tell individuals how the proposed changes would benefit them as individuals or what they would cost, nor will it provide a formula or mechanism to determine what the individual benefit or cost would be.

This analysis only assesses the costs and benefits associated with the differences between the current water quality standards rule and the proposed rule. These are the incremental changes that would occur as a result of rule adoption. In many cases, there would be no increased costs. For example, we estimate that there will be no additional impacts to the agricultural community beyond those associated with meeting the current water quality standards, nor will forest harvest practices designed to protect water quality or existing best management practices for addressing stormwater need to alter from what is currently required. We have attempted to determine costs to potentially affected businesses that have direct discharges to the water. This is challenging, and we hope to get feedback on our assumptions and estimates.

It is difficult to put a dollar figure on the benefits associated with clean water and a healthy ecosystem. We have attempted to do this by focusing on the fish resource, but we recognize there are no agreed upon methods to actually place a dollar figure on a resource that has such a significant cultural and spiritual value to Washingtonians. We also recognize that there are benefits from environmental factors that cannot be quantified, and this may tend to result in an under-valuation of the specific environmental resource being addressed.

Please provide us with feedback on the assumptions and methods we have used in this document so that we will have the best available information in making our final determination as to whether the benefits of these proposed rules exceed the costs. We need your comments by April 22, 2003. They should be sent to Cathy Carruthers, Department of Ecology, P.O. Box 47600, Olympia, WA 98503 or via e-mail at caca461@ecy.wa.gov.

As always, thank you for your help.

Draft Cost-Benefit Analysis for Public Comment

Draft Benefit-Cost Analysis for Public Comment

Proposed Changes to Chapter 173-201A WAC
Water Quality Standards for Surface Waters
April 1, 2003

The Washington Administrative Procedures Act, RCW 34.05.328(1)(c) requires that an agency determine that the probable benefits of rule amendments are greater than its probable costs before adoption of a rule. The agency must take into account both qualitative and quantitative benefits and costs and the specific directives of the statute being implemented.

The Department of Ecology (Ecology) has put together this draft document for comment to assist with the determinations regarding the probable net benefits of several parts of the amendments to WAC 173-201A Surface Water Quality Standards. Ecology reviewed the proposed amendments to the following requirements which are inextricably linked together: Bacteria, Temperature and Dissolved Oxygen, and Irrigation Water Criteria.

- This draft indicates the bacterial amendments are unlikely to meet the net benefits requirement. See the section *Cost Benefit Analysis for Bacterial Standards.*
- The probable benefits of the temperature and dissolved oxygen standards exceed the probable costs for some classification shifts if fish populations are sufficiently increased. See the section *Cost Benefit Analysis for Dissolved Oxygen and Temperature Standards.*
- The irrigation supply water criteria may meet the net benefits requirement, but full evaluation is not possible given the fact that quantitative information on both the benefits and costs is extremely limited. No current costs are expected and any agricultural gains are expected in the distant future. See the sub-section, *No Impact for Agricultural Water Supply Criteria*.

This document starts by discussing the general terms that apply to the analysis of each element of the rule listed above. This is followed by the evaluation of each element. The conclusion is then listed followed by supporting information. If possible, benefits and costs are quantified. Unquantifiable elements are described.

Proposed Changes to the Rule

The following are brief descriptions of the rule changes. A more detailed description of the proposed changes can be found in both the decision memos and the draft environmental impact statement which are both a part of the proposed rule package. A crosswalk of the proposed changes and their stringency compared to federal regulations is in Appendix A.

Proposed Antidegradation [Part III 173-201A-300 through 330]: This section has been rewritten and greatly expanded. However, the changes either: 1) are a form of cost reduction or 2) make requirements that are implicit in the existing rules explicit. Therefore no cost was modeled.

Use Based Format for the Standards [contained in 173-201A-200, 600, 602]: The proposed amendment shifts the classification system to a use basis. Uses are defined and the regulation applies the most stringent standards that support those uses in each case. The proposed classification system only has an impact on business through the change in the criteria (e.g. dissolved oxygen) and the change in the waterbody reaches (e.g. Class A to Char). Thus the proposed reclassification is analyzed through these changes. In the longer term, improved information will allow the deletion of certain uses from specific waterbody segments, potentially easing the long-term burden of the regulations.

Temperature standards [contained in 173-201A-200, 173-201A-210]: Temperature standards would be either reduced or increased for some fresh water reaches. The metric used to express the temperature standard would also change from an "instantaneous daily maximum" to a "7 day average of the daily maximum" (7-DADMax). For an average water body with continuous temperature monitoring, the 7-DADMax measure is 1 degree lower than the instantaneous daily maximum measure. Diagram 1 shows the differences between the existing rule and the proposed rule. There are no proposed changes for marine waters.

Diagram 1: Summary of Transition to Proposed Temperature Criteria

Existing Standards	Proposed Standards (with approximate daily maximum equivalents in parenthesis)
Class AA water bodies – 16ºC daily maximum	Char – 13ºC 7-DADM (approximately 14ºC as a daily maximum)
Class A water bodies – 18ºC daily maximum	Salmon Spawning and Rearing – 16ºC 7-DADM (approximately 17ºC as a daily maximum)
Lakes – no change	
Class B water bodies 21ºC daily maximum	Salmon Rearing Only – 17.5ºC 7-DADM (approximately– 18.5ºC as a daily maximum)

Waterbody reaches, including lakes, which naturally exceed the current standard are already limited to a .3ºC change in temperature. Businesses in naturally limited reaches will be unaffected by the new standards. If the temperature criteria for a water body are increased the businesses will benefit. **Only activities located in specific waterbody reaches will be more constrained. These are reaches where (1) the stream does not naturally exceed the current standard and where (2) the proposed temperature standard is lowered**.

Heat plumes in mixing zones [173-201A-200 (1)(c)(vi)(C)]: Heat plumes would be required to meet a temperature of 33ºC, 2 seconds after leaving the pipe. This would impact point source dischargers that have high temperature discharges that might exceed these criteria. This situation did not appear to be a problem for facilities in our survey so we did not have data to quantify the cost impact.

Dissolved oxygen standards (DO) [contained in 173-201A-200(1)(d)]: DO standards would be reduced or increased in many fresh water reaches (including lakes). There are no proposed changes for marine waters. DO measurement would change to two metrics: a long-term 90-day average of the daily minimum and a short-term one-day minimum would be used. The daily minimum would be reduced, which should make the standard easier to meet. However, the 90-day average, might be harder to achieve. The DO standard would increase for some waterbody reaches and would be reduced from “allows no change” to a numeric standard of 9.5 mg/l for lakes. In some places the DO requirements would increase (See Diagram 2).

Diagram 2: Summary of Transition to Proposed Dissolved Oxygen Criteria

<u>Existing Standards</u>		<u>Proposed Standards</u> (with approximate daily minimum equivalents in parentheses)
Class AA water bodies – 9.5 mg/L daily minimum Class A water bodies – 8.0 mg/L daily minimum Lakes – no change	→	Salmonid Spawning and Rearing – 9.5 mg/L 90-day average of daily minimums (approximately 8.5 mg/L as a daily minimum) and 7.0 mg/L daily minimum
Class B water bodies – 6.5 mg/L daily minimum	→	Salmonid Rearing Only – 8.5 mg/L 90-day average of daily minimums (approximately 7.5 mg/L as a daily minimum) and 6.0 mg/L daily minimum

Where the natural level of DO is already lower than the current standard, there will be no change for businesses. This situation forms part of the basis for the worst case analysis.

<u>Bacteriological standards</u> [173-201A-200(2), 173-201A-210(1)(g) and (2)(b)]: The proposed rule uses *E. coli* as the bacterial indicator for fresh water and enterococci as the bacterial indicator for marine water rather than the current fecal coliform test. Where there are shellfish beds in salt water recreation areas there will be no change because the shellfish criteria dominate. See the section *Cost Benefit Analysis for Bacterial Standards.*

<u>Agricultural water supplies</u> [173-201A-200(3)(b)]: The proposed rules would set standards to protect the quality of water diverted for agriculture. This would mean additional criteria would be applied to all water bodies where agricultural water supply is a beneficial use. Since use of waters for irrigated agriculture is widespread, the proposed criteria will be broadly applied to rivers, lakes, and reservoirs throughout the state.

General Elements of Analysis

Weighing Benefits Against Legal Mandates

Three key legal foundations paramount in setting targets for state water quality standards:

- **State Law (Chapter 90.48 RCW and Chapter 90.54 RCW);**
- **Federal Law (Clean Water Act and associated federal rules at CFR part 131); and**
- **Treaty Law (Obligations to protect resource use created by the federal agreement).**

All three of these legally binding doctrines create complimentary obligations for the state Department of Ecology when establishing water quality standards:

- **The highest attainable level of protection for uses and water quality are to be supported by state standards;**
- **Viable and robust populations of all indigenous species must be maintained or restored where feasible; and**
- **Surplus fish for human use should be ensured.**

While the above obligations are complimentary and directive, so is the need to consider how the standards affect human industry. State standards must be set so that they accomplish the above objectives with the least excess costs and impacts to human activities. This requires careful balancing and is reflected through measures such as:

- **Avoiding the imposition of criteria more stringent then determined appropriate to meet legal obligations and meet project objectives;**
- **Avoiding duplicative monitoring requirements or more costly sampling and analysis requirements;**
- **Selecting the least burdensome implementation procedures; and**
- **Tempering corrective actions to the urgency and conditions appropriate to individual circumstances.**

In setting or revising water quality standards these factors combine to create a clear legal obligation to: **select the least burdensome approach to fully protect beneficial uses (e.g., recreation in and on the water, fish and wildlife) and the water quality that maintains those uses.**

There is not flexibility for the agency to choose not to set water quality standards in a manner consistent with these legal obligations. For the purposes of a review under the State Administrative Procedures Act (Chapter 34.05 RCW) these obligations form the goals for this rulemaking. All changes must be reviewed within the context of these goals.

The costs of not complying with these legal obligations combined with the monetary and societal values accompanying clean water and healthy fish populations, when viewed in the context of the decisions that minimize extraneous costs to industries and others, outweighs the probable economic costs to industries and others for complying with the proposed rules.

Conservative Estimates

Throughout this analysis the estimates are made in a conservative fashion. This means that many of the selected values have a bias against the changes in the rule. Where this was not possible this is stated in the area where the number was used.

Rule Clarity

During the rule development process, Ecology evaluated the rule to incorporate "plain English" for greater understanding. More sections were added to the regulation to allow a person to more easily find a subject she/he is interested in. A new "tools" section was created to provide more detailed information on application of criteria and uses. This qualitative value accrues to all sections.

Time horizon

Ecology has selected a 20-year time horizon. Summed values in the analysis are based on present values over this 20-year span.[1]

Several things argue for a short time horizon. The evaluation takes place at a time of higher unemployment and business failure when change is often more rapid than usual. Further, switching to use driven standards will allow changes in uses to be made more easily based on appropriate scientific evidence regarding a specific water body. For example if a waterbody is identified for use by salmon, and in fact no salmon use the water, the use can be changed to another aquatic life category, such as warm water species in a future rule change. The standards are reviewed every 3 years. Further, the technology available changes over time. As an example, new membrane technology has the potential to significantly reduce the cost of removing biological oxygen demand. Given this, it is not warranted in assuming that the rule amendments will be permanent.

On the other hand, several things argue for a longer time horizon. It has been 10 years since the last major revision and it will probably take at least 10 years to update associated permits. The proposed standards are based on a combination of best available science and economic

[1] The interest rate, or social rate of time preference, for this analysis was taken from interest rates on inflation protected government bonds. Generally the value used was 1.6% based on the current offerings of the US Dept. of Treasury. The fish population benefit uses 1999 interest rates (3.63%) because this is the value that was available to people at the time that the survey was done. This dichotomy is conservative, or biased against the rule, in that the costs are discounted less steeply than the benefits.

feasibility. Fish population impacts take several years beyond the final implementation of the rule to be realized. Some salmonid populations in particular have a long breeding cycle. There is a study of how much Washingtonians are willing to pay to preserve salmonids. This study estimated a present value for actions taken over the next 20 years. As detailed below, this "existence value" is a large component of the analysis performed here. Finally, the capital for a treatment plant has an approximate life-span of 30 years, but changes may be made to these plants on as frequent as a 5 year schedule. Within 15 to 20 years the plant operation can be adjusted substantially through upgraded replacement technology.

Costs to Sectors

The proposed amendments are expected to have an impact on point source permits but not on nonpoint activities such as agriculture, forest practices, or stormwater, as outlined below.

1. **Point Sources**: The proposed rule may affect permitted point source facilities in a variety of sectors. These sectors and the number of permits[2] the facilities hold are listed in Table 2.[3] The impact on permitted activities would depend on:
    - Whether the activity is located on a waterbody reach where the water body is not already listed as impaired,
    - Whether the incremental change in the standards will require a permit change, and
    - The mechanism a permitee chooses to use to attain compliance.

2. Some **POTWs** (Publicly Owned Treatment Works), which discharge to surface water, would be affected by the proposed amendments.

3. **Nonpoint Sources** (for more information on how Ecology regulates nonpoint activities go to Appendix A)
    a. Stormwater may also affect water quality. Ecology's expectation is that the proposed changes to the standard will not require any substantive changes in currently accepted stormwater practices because current practices represent the best available methods for managing urban stormwater.[4]
    b. Forestry activities are covered under the Forest and Fish rules. The rule amendment will not require any substantive changes in currently accepted forestry practices (see Appendix A).
    c. Agricultural practices also affect water quality. The suggested best management practices to protect water quality are unlikely to shift as a result of the incremental changes in the standards. This is because agriculture relies on broad best management practices. These practices have broad guidance and compliance with these is likely to comply with both the current and the proposed standards. (see Appendix A)

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[2] Unaffected marine and stormwater permits were not included in the count. Simply being listed here does not mean there is necessarily a cost increase to the facility.
[3] The companies affected may hold more than one permit. The "*" means there are fewer than 3 companies.
[4] Bill Moore, Environmental Engineer, Water Quality Program, Department of Ecology.

Neutral Changes

The following items are expected to be neutral and have not been analyzed.

- The antidegradation section has been expanded to include more details on implementation. The changes make the requirements currently in this section more explicit. The current antidegradation section does not contain any details regarding the Tier II analysis. It does not spell out specific actions that must undergo a Tier II analysis but instead is written broadly in terms of the goals for the waterbody. Broadly interpreted, the existing regulations could be interpreted to have a zero threshold for action on the part of Ecology, and it leaves open to agency judgement what types of activities would need to comply. A significant amount of detail was provided to the Tier II and Tier III sections in order to describe how these tiers are to be implemented. For example, Ecology carefully considered which activities should undergo a Tier II analysis and which activities would not be required to go through an analysis, and set reasonable limitations on how antidegradation will be implemented. The limitations could be viewed as a form of cost reduction from the existing regulation. Tier II analyses includes an evaluations of alternatives and a determination of overriding public interest. In some cases, this analysis might be very simple. This would include situations where alternatives have already been evaluated. In other cases, however, this analysis might require more work and more time. Because Ecology's proposal makes the existing regulation more explicit, and provides cost reductions by limiting how antidegradation is applied, the costs of this section are considered neutral and no cost was modeled..

- The proposed adjustments to the freshwater ammonia criteria should provide reasonable levels of protection for fish and other aquatic life, and are also slightly less stringent than the existing ammonia criteria. The existing chronic ammonia criterion for waters where salmon habitat is a designated use is not proposed for change. This chronic criterion is the driver for most ammonia effluent limits for point source dischargers, and the proposed relaxation of the remaining ammonia criteria (in non-salmonid waters) will result in little or no change to effluent limits. Because effluent limits for ammonia are in general not driven by the criteria that are proposed for adjustment, the cost to point sources required to comply with the ammonia criteria should not result in any additional costs. The slight loosening of the ammonia criteria should not result in any additional effects to fish or other aquatic life.

- A new tools section has been added to the rule in Part 4 (sections 400-450). These sections describes tools for application of the uses and criteria, and are not mandatory. Therefore, the costs are considered neutral and not cost was estimated.

Extinction risk

Extinction was not considered in this document because the proposed amendments by themselves are unlikely to either cause or eliminate the possibility of extinctions. The temperature changes may reduce, to some extent, the risk for some of the Char populations. Likewise the changes in the Class AA to Salmon Spawning waters appear to impact some runs.

But it is unlikely to generate extinction. If the rule were to cause extinction the values would be very large. Pauley[5] makes the point that extinction would be a breach of treaty, for which Tribes gave up 40 million acres, have suffered 34,000 acres flooded tribal burial grounds, and lost 338,000 acres of flooded hunting and gathering grounds. Extinction thus may have very high values.

Quantification Difficulties

The cost of environmental regulation and the public benefits that are derived from environmental factors, such as clean water, can be described, but placing dollar figures on the costs and benefits of environmental protection is often difficult for reasons outlined below.

Given the existing regulatory structure in the United States, our water is well protected in comparison to many other parts of the world. In Washington the benefits and costs are less dramatic and costs and benefits are often institutionalized and therefore harder to quantify.

Humans and animals are dependent on the environment for sustenance, such as for the air we breathe and the water we drink. Quantifying subsets of that environment, and then placing an even more specific dollar value on that subset based on its relative quality is not an easy task. This analysis is only based on monitorable shifts rather than generating a complete picture of the total value accruing to the changes. For example:

- The cost of a change in a wastewater treatment plant can be estimated and the additions to water bills can be estimated. But it is very difficult to estimate the value of using that water to individuals who would then be required to pay a higher water bill. One person may not be affected at all by the increased cost of using the water, while another person may find any increase in costs a financial burden.

- The benefit of the irrigation water supply criteria would come from long term potential reductions in damages to agricultural land. These cannot be estimated because the trend in the levels of bicarbonate cannot yet be identified, given the data, and detailed financial impacts to agricultural operations due to poor water quality are not well established.

Benefit estimation

In general, the benefits that are derived from maintaining the quality of the environment are undervalued. Reasons this can occur include:

- the inability to predict what will occur in the future;

- incomplete data about the current environmental system being examined; and

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[5] Pauley, Stephen M. (1999), "Our responsibilities to the Native American tribes of the Columbia and Snake basins," http://www.idahorivers.org/nativeamerican.htm, accession July 17, 2002.

- increasing population and wealth tends to increase demand for environmental benefits, but also increase demands on the environment itself in order to maintain the population and increased wealth.

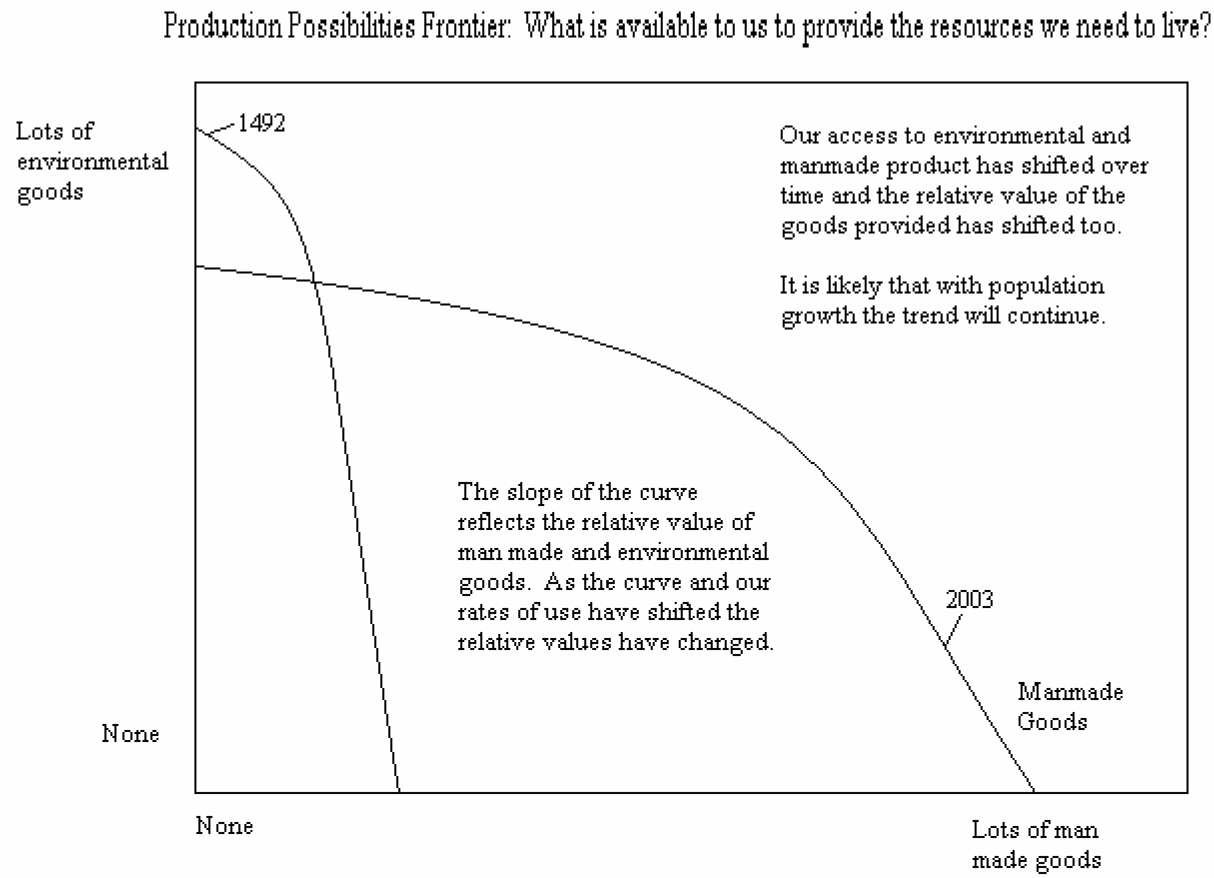
Lack of knowledge about the future is a critical reason for undervaluing environmental qualities. Inability to predict future public needs means we cannot calculate the future benefits from specific environmental factors. For instance, forty years ago a valuation of the benefits of protecting rainforests might have focused on sustainable harvest (for food) of plants and animals associated with specific forest environments. With the advent of genetic engineering and an upsurge in interest in plant-based chemicals for pharmaceutical use, a present-day effort to place value on the benefits of rainforest would include this new potential benefit.

The effects of the loss of a species are also difficult to value prior to the loss. Sometimes we do not value things until it is too late. The passenger pigeon was sold in New York right up to the time it went extinct and the price never wavered because there were so many substitutes. However, when the last one died it created a sense of outrage that drove a wide variety of environmental and hunting reforms.

Incomplete data about the specific environmental system being examined is another reason environmental qualities might be undervalued. For example, in studies of salmonids over the past decade information about the role they play as nutrients to the watershed around their spawning areas has been documented. Nutrient transfer occurs when wild animals remove salmon carcasses from the river after spawning. The nutrients from these carcasses are transferred up into the watershed either as direct remains of the carcasses or in fecal matter from the animals ingesting the carcasses.[6] The nutrients from salmon help support the forests and the associated animal life in the areas adjacent to spawning streams. Additionally, the nutrients brought into the system by the fish help support animals and plants that people do not traditionally use but are necessary for the system to function. Even if these organisms are identified, they may be undervalued because their roles are not recognized. In both of these ways incomplete scientific knowledge of environmental systems limits the ability to examine all the potential benefits associated with a specific environmental factor.

[6] Naiman RJ, Bilby RE, Schindler DE, Helfield JM. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems, 5:399-417. Bilby RE, Fransen BR, Bisson PA, Walter JK. 1998. Response of juvenile coho salmon (Oncorhynchus kisutch) and steelhead (O. mykiss) to the addition of salmon carcasses to two streams in southwestern Washington, U.S.A. Can J Fish Aquat Sci 55:1908-18.

Graph 1



Another way that inability to know the future hampers economic analysis has to do with the relative rarity of resources. In the past there were lots of environmental resources and very few man made goods. People were willing to trade off lots of environmental goods for a man made one (see the slope of the line in the graph as the rate of trading off environmental and man made goods). In the future, as environmental resources become scarcer relative to the size of the population and other man made products (such as TVs) become less scarce, people might be willing to trade off more man made goods to maintain environmental resources. This will be reflected in a higher "willingness to pay." This has already been happening to some extent, for example recycling replaces mined product, people vote for local revenues for waste water treatment and support environmental legislation.

Cost Estimation

Sometimes, but not always, the cost of environmental protection can be overestimated or unrecognized. This is generally a result of the following factors:

- An adaptive economy (cost overestimated)
- Technology available to polluters may change and reduce costs (cost overestimated)
- The assimilative capacity of the environment may be exceeded (cost unrecognized)
- Uncounted consequences to individuals (cost unrecognized)

An adaptive economy

One of the important shifts made by the proposed change to the water quality standards is that it tends to improve the long term ability to make innovative choices and adapt. This is an important shift in approach to regulation and cost control. These provisions are described as follows.

- The anti-degradation language ensures that the assimilative capacity of the state's waters is allocated to higher value economic activities or sustained long-term economic development. It does this by requiring a showing of overriding public benefit before water quality can be lowered. This may impose costs on some entities and mean substantial savings for others. The inclusion of the anti-degradation aspect makes the costs of the overall rule more difficult to quantify. It will apply to specific watersheds, but as that water passes into the next waterbody, the high water quality will reduce the costs for dischargers down stream.

- 173-201A-320(4)(a)(iii): Antidegradation encourages the use of innovative pollution control and management techniques, which may be an advance in AKART (All Known, Available, and Reasonable methods of prevention, control, and Treatment).

- 173-201A-320(4)(b)(viii): Allows for the use of water quality offsets in meeting antidegradation requirements. Offsets would allow an expanding activity to purchase pollution reduction from other sources to offset a new highly valued activity.

Some sections were designed to make the rule more likely to generate reasonable decisions, rather than driving unnecessary changes in permits.

- 173-201A-200(1)(c) and 200(1)(d): The revised temperature and dissolved oxygen criteria have been designed to avoid unnecessary impact on human economic activities and to allow for reasonable implementation. Revisions include:
  (a) Selecting criteria from the midpoint of the range that bounds the estimate of what maximum temperatures or dissolved oxygen are needed to fully protect species;
  (b) Applying the criteria based on general patterns of stream use and species mixes;
  (c) Not basing recommendations on individual studies;
  (d) Recognizing longer-term averaging periods, where appropriate, when developing the recommended criteria;
  (e) Where natural conditions of a waterbody do not meet the criteria, a small allowance for human activities is allowed to be factored in to permits and pollution reduction plans;
  (f) An allowance that criteria can be adjusted to account for the thermal effects of permanent human structural changes;
  (g) In order to make permitting; and modeling more accurate and effective, a provision was added that states that temperature and dissolved oxygen are not to exceed the criteria at a probability frequency of more than once every ten years on average.

- 173-201A-260: This section contains provisions for applying general criteria, including:

(a) A provision that allows the natural condition of a waterbody to become the alternative criteria target for a waterbody when the criteria itself cannot be met.
(b) A provision that numeric criteria established in this chapter do not apply to human-created waters managed primarily for the removal or containment of pollution. This includes private farm ponds created from upland sites that do not incorporate natural waterbodies.

- 173-201A-320: The antidegradation section that requires a more detailed analysis from applicants of water quality permits is limited to new and expanded actions that have a measurable change in water quality. This limitation assures that resources are spent on those actions that will cause a measurable change, and therefore not require resources to be used on insignificant actions.

- 173-201A-320(6): Allows for general permits and pollution control programs to go through an antidegradation analysis at the time the permit is developed and not for each individual action covered by the general permit or pollution control program. Since many activities for small businesses may be covered by general permits or programs, this will be a cost savings in terms of not having to provide individual analyses.

- 173-201A-320(6)(c): Allows adaptive management to be used with nonpoint source programs and general permits to avoid over-application of control measures and to phase in requirements over time.

- Part IV-Tools for Application of Criteria and Uses: This new part in the rule provides several tools that are available for applying alternative criteria or uses. These tools include provisions for:

  (a) 173-201A-410: Allows on-going short-term modifications of water quality. The amendment moves the longer duration approval authority with the use of management plans from the subsection on pesticides to its own subsection that can apply to any short-term activity. Thus the flexibility is more broadly provided.
  (b) 173-201A-420: Variances would allow criteria to be modified for individual facilities, or stretches of waters on a longer term basis.
  (c) 173-201A-430: Site specific criteria may be developed after determining that the criteria designated for a waterbody cannot be attained due in part, or whole, to natural climatic or landscape attributes, or irreversible human changes or due to differences in local species sensitivities to pollutants.
  (d) 173-201A-440: A use attainability analysis may be done to remove or modify a designated use for a waterbody that is neither existing nor attainable.
  (e) 173-201A-450: A water quality offset occurs where a project proponent either implements or finances the implementation of controls for point or nonpoint sources otherwise under the control of other entities. This offset is undertaken to reduce the levels of pollution for the express purpose of creating sufficient assimilative capacity to allow new or expanded discharges. The goal of water quality offsets is to reduce the pollution levels of a waterbody sufficiently enough that a proponent's actions are not

causing, or further contributing to, a violation of the requirements of this chapter and result in a net environmental benefit.

- 173-201A-510(5): Some dams don't currently meet water quality standards (e.g. total dissolved gasses, temperature). This section allows Ecology to issue a water quality certification for re-licensing of the dam through a compliance schedule, rather than disapproving the certification.

- Allows re-designation of rivers and streams based on the actual use of the waterbody (found in 173-201A-200 & 210, and WAC 173-201A-600 & 610)

An economy is an adaptive system, and future adaptations are inherently hard to foresee. Faced with a new situation, people on the ground come up with solutions that no expert can see in advance. This means that when we predict the cost of a restriction on the economy (like a regulation), we are likely to overestimate the cost.

This is not an abstract idea, but very real history, as illustrated by the predictions of massive regional economic losses in response to revised forest provisions.[7] Predictions that reduced tree harvests would cripple the region's economy were followed by a decade of fast regional economic growth – along with reductions in harvest.

Technology Available to Polluters May Change

This proposed rule amendment has criteria that are more flexible than permits, which might otherwise require a specific machine be used to reduce contamination. This allows the permitee to decide what equipment and method to use to meet the standard. Where innovation is permitted, such as the offsets allowed under antidegradation,[8] costs can be far lower than the expected costs. EPA has estimated that significant cost reductions would occur as a result of a flexible approach to TMDLs:

> "The National Cost to Implement Total Maximum Daily Loads (TMDLs) Draft Report estimates that flexible approaches to improving water quality could save $900 million dollars annually compared to the least flexible approach (EPA, August 2001). Nitrogen trading among publicly owned treatment works in Connecticut that discharge into Long Island Sound is expected to achieve the required reductions under a TMDL while saving over $200 million dollars in control costs."[9]

For example, when the Clean Air Act was passed, industry argued that the cost per annual ton year of sulfur dioxide reductions would be approximately $5,000. EPA expected costs of $2,500 per annual ton year. The $2,500 per annual ton year became the sale price for new emissions in a trading program designed by EPA. The Chicago Board of Trade now provides for sales of

[7] Niemi, Ernie, Ed Whitelaw, and Andrew Johnston, (1999) *The sky did not fall*, ECONorthwest; http://www.salmonandeconomy.org/pdf/SkyDidNotFall.pdf, accessed May 22, 2002.

[8] WAC 173-201A-450

[9] Quote from http://www.epa.gov/owow/watershed/trading/finalpolicy2003.html downloaded 3/20/2003.

sulfurdioxide emissions rights by either EPA or private parties. The prices of the private trades at the Chicago Board of Trade are an order of magnitude less than these early expected costs per ton year. In 2003 the market clearing price for current year emissions was $171.80. The market clearing price for seven year advance bids was $80.[10]

It is reasonable to assume that meeting the proposed new standards will require changes in how some economic activities are carried out, that some of those changes will be costly, and that these costs will be unevenly distributed even within the particular sectors affected. However, it is also reasonable to bear in mind that prospective estimates of this type are likely to overstate the truth.

Growth areas are unpredictable. Every few years, new technology or new methods stimulate a new area of enterprise. This benefit cost analysis is a snapshot at a point in time, and reflect the economy and prices as of this writing. The costs and benefits shift with changes in the direction of growth in business areas. For example, in doing this analysis granulated media filters are currently the dominant technology. But membrane filters, which are expected to be less expensive and just as effective at reducing biological oxygen demand are being introduced rapidly.[11]

There are two fundamentally different views of what makes an economy prosper. In the older view, the key to wealth is the extraction of resources from the environment at the lowest expenditure in human labor and human-made capital. Anything that makes this extraction more expensive hobbles the economy.

There is an emerging view in which economic prosperity is a process and a set of skills, rather than a collection of things or a specific level of agricultural harvests. People still have to eat food and heat their houses, so physical resources are necessary, but society can do these things in many ways. More importantly, unimpeded access to natural resources is not sufficient for prosperity. All the natural resources under the sun will not create prosperity where a society is not structured to make efficient use of the resources extracted. Intangibles such as the habit of innovating and networks of economic agents can create wealth on a small natural-resource base, while abundant resources will lie fallow without these social structures to use them well. The fact that the price of fish has fallen at the same time as the catch has dropped [see graph 3] is an indication of the power of an economy to adjust to a massive shift in the availability of a renewable asset through imports and aquaculture.

This has a very important implication for the economic impact of the proposed standards. In the real world there would be levels of protection that are obviously too weak (e.g. no requirements), and levels that are obviously too stringent (e.g. no discharges). But there is a relatively wide zone within which the exact level of regulation is less important than the way in which the regulation is structured. A prescriptive rule would tell industries and farms exactly what technologies to use, under the assumption that this would accomplish a specific environmental

[10] EPA, http://www.epa.gov/airmarkets/auctions/2003/03spotbids.html, http://www.epa.gov/airmarkets/auctions/2003/09advbids.html

[11] One company which had a website on its granulated filter was questioned about costs and responded that they had just shifted to a membrane filter.

outcome. It would also be a much easier rule on which to perform a benefit-cost analysis, because the cost-incurring actions would be spelled out in the rule, rather than having to be inferred. The technologies specified may not be the least-cost path to the desired outcome, and the specification itself stifles economic creativity, or channels it into the search for ways around the rule. The incentive for innovation and adaptation is hobbled, and the economy may be crippled in ways more far-reaching than merely the obvious matter of making access to natural resources more expensive.

This proposed rule amendment is outcome-based rule in contrast to a prescriptive rule. It focuses on actual uses of the water, and it leaves the exact methods of compliance up to the individual regulated entities. For example a company may choose to use a water tower to cool water or to do stream restoration that provides shade and cooling. While there may be some increase in the cost of access to natural resources, the more important economic asset – people's ability to adapt and find innovative solutions – is unaffected.

Assimilative Capacity May be Exceeded

In some cases the survey of permits revealed that the receiving waters were already out of compliance with the existing rule. The assimilative capacity of the environment is limited and must be divided over multiple uses. Once the assimilative capacity has been reached it becomes more costly to generate discharges. Losses may be imposed on downstream users as the permitees have to share the capacity. For example, possible downstream losses to permitees from upstream use of temperature capacity were not quantified.

Uncounted Consequences to Individuals

All that being said, it is still possible that an economic analysis will overlook costs. If water bills go up, for example, low income people may cut back on their use of water in ways that those with sufficient income would never consider.

Effect of the Antidegredation Amendments

Another quantification difficulty is trying to determine the benefits derived from the antidegradation section of the water quality standards. The antidegradation is intended to prevent or minimize waters of higher quality from being degraded down to the criteria. When evaluating the costs and benefits of the proposed criteria changes (bacteria, temperature, and dissolved oxygen in particular), the pollution prevention affects of antidegradation should be taken into account. For example, even if a current Class AA water is proposed to be protected at a new bacteria limit that is less stringent than the current criteria, the antidegradation section will not allow the water to automatically be degraded to the less stringent limit. Likewise, for current Class AA waters the proposed change in temperature limits will on average result in a 1°C increase in allowable summer temperatures. However, Class AA waters that have cooler temperatures will not automatically be allowed to warm up to the proposed standard because antidegradation rules must be applied.

Quantifying the benefits of antidegradation, however, is very difficult and cannot be reliably done because of the conditions, limits and allowances built in to the rule on when and how antidegradation is applied. Therefore, in estimating the qualitative costs of temperature and dissolved oxygen, the net benefits of an antidegradation program were not specifically factored in.

Resistance to quantifying values

Some values are unquantifiable because people feel so strongly about the issue that they will not talk with a researcher about it. Some tribal members experience moral outrage when they are asked how much they would pay to add fish to a declining fish population. A mother who can no longer allow a toddler to play in the sprinkler because of water bills may hang up on a survey caller. This doesn't mean they don't value the object. To the contrary the loss is already great and they won't quantify it.

Tribal Values for Water Quality

Quantifying the value of clean water in the protection and continuation of tribal fisheries is extremely complex and may ultimately be impossible. From the earliest of known times, tribal communities in Washington State have been heavily dependent on anadromous fish for their subsistence and for trade. Salmon is and was a central part of tribal cultural and religious practices. Today all of these uses continue throughout the state both on reservation and off reservation under treaty rights. There are currently 29 federally recognized tribes and 27 Indian reservations within Washington State. Twenty-one of the tribes of Washington State have been recognized by the federal courts as treaty tribes who, under the Stevens' treaties, ceded vast areas of land to the United States while reserving certain off-reservation rights including the right to take fish in their "usual and accustomed" places and the right to hunt on "open and unclaimed lands". In addition to the tribes in Washington State, two tribes located in other states, the Confederated Tribes of the Umatilla Reservation in Oregon and the Nez Pierce tribe of Idaho, have ceded usual and accustomed fishing areas in Washington State. The rights of Washington tribes to take fish for commercial, subsistence and ceremonial purposes under treaties have been extensively litigated in United States v. Washington.

The following two comments from tribes on the proposed water quality standards illustrate the difficulty of assigning a dollar figure to the tribal benefits of these resources:

Squaxin Island Tribe:

"The Squaxin are descended from maritime people who lived and prospered along the shores of the southernmost inlets of Puget Sound for untold centuries. Delicacies offered from the sea such as clams, oysters and salmon, have always been highly valued by tribal members. The aquatic creatures that sustain us offer much more than mere physical nourishment; they are an essence of our culture and traditions making them essential to our survival as people. This long history of association with the sea has made the Tribe a very committed steward of clean water in order to protect our heritage.

The United States first recognized the Squaxin Island Tribe in the Medicine Creek Treaty signed in 1854, ratified by the United States in 1855 and thereafter signed by President Franklin Pierce. With his signature, it became the supreme law of the land and Tribal recognition and sovereignty have continued to this day.

The original reservation was established on Squaxin Island. The island sits at the head of seven inlets of Southern Puget Sound – Case, Hammersley/Oakland, Totten/Little Skookum, Eld, Budd, Henderson and Nisqually/Carr inlets. More recently, lands on the mainland in Kamilche near Little Skookum Inlet were put into trust for the Tribe by the federal government.

The marine waters surrounding the island and all the water flowing off the land and out of the ground in numerous watersheds surrounding the seven adjoining inlets influences the health and function of the Tribes Natural resource. These lands and waters comprise the Tribes usual and accustomed fishing stations and grounds – our treaty fishing area.

The protection and restoration of our natural resource base is essential to the economic well being and cultural survival of the Squaxin Island Tribe. The Squaxins reserved these rights when the treaty was signed. Without adequate protection of water quality, the Tribe cannot exercise these reserved rights."[12]

Puyallup Tribe:

"The value of our Reservation and the natural resources upon which tribal members rely for subsistence as well as their cultural and spiritual well-being are priceless. Additionally, the Puyallup Tribe has spent tens of millions of dollars in the past 15 years in salmon recovery; hatchery operations and fish production; habitat restoration projects and water quality regulation development."

"The Puyallup Tribe of Indians Land Claims Settlement Act of 1989 (Public Law 101-41) established criteria for the protection of the tribe's fishery as well as the health, safety and welfare of the Tribe. The Settlement Act of 1989 envisions a permanent homeland for the Puyallup Tribe. Indian reservations are unique for all practice purposes in that they are not being made anymore. Tribal members do not have the same flexibility in moving away from their homeland, as do many other U.S. citizens. Tribal members have cultural, as well as spiritual ties to the land, air and water that form their homeland."[13]

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[12] From comment letter on proposed water quality standards to Megan White from John Konovsky, Squaxin Island Tribe, 2/26/03

[13] From comment letter on proposed water quality standards to Tom Fitzsimmons from Bill Sullivan, Director, Natural Resources for the Puyallup Indians, 2/7/03

No Impact for Agricultural Water Supply Criteria

Four criteria are proposed to protect agricultural water supplies (Bicarbonate, Conductivity, pH, and TSS[14]).

The pH criteria will have no impact. The proposed pH criteria for water supply protection is less stringent than the criteria that would be applied in the same waters to protect aquatic life uses. Bicarbonate and conductivity appear to be near the proposed criteria in some waters where the criteria would be applied, but none were found that exceeded the criteria at this time.[15]

The one parameter for which there appears to currently be problems with attaining the proposed criteria across the state is the TSS criteria. The criteria proposed for TSS is 75 mg/l as a six-month arithmetic average. To determine if point sources would likely be impacted by this parameter, Ecology examined the permitted discharge limits for 367 individually permitted facilities. Out of the 367 individual permits, only one freshwater discharger had a monthly limit above the proposed TSS criteria of 75 mg/l. That one food processing permit had a monthly average limit of 175 mg/l. To meet the proposed TSS criteria limit, the facility would potentially need to produce lower monthly averages. That permit limit is also measured in 100% effluent without any allowance for available dilution with receiving waters, so with moderate dilution the discharge would not likely exceed the proposed water quality criteria. Numerous permittees had effluent limits that were at 75 mg/l, but the vast majority of the permittees had limits that met the state's technology-based limit of 30 mg/l as a monthly average for municipal wastewater treatment plant effluent. Thus it appears that the proposed criteria for agricultural water supply protection poses little if any chance of creating cost obligations for any of the state's existing point sources permit holders.[16]

Cost Benefit Analysis for Bacterial Standards

The bacterial portion of the proposed rule is not expected to generate probable benefits that exceed the probable costs. The total expected present value of new illness ranges from $14 to $21 million. The total cost of the shift to a new lab test, extrapolated over a 20 year period is approximately $3.6 million. The benefits are expected to be minimal. Therefore the rule change is expected to generate net costs that range from $17 million to $24 million.

Net Benefits

The bacterial portion of the proposed rule is not expected to generate probable benefits that exceed the probable costs. The draft Cost benefit analysis shows that costs accrue to the public in the form of increased cases of gastroenteritis. Costs may also accrue to the permitees that measure for Fecal Coliform and who would have to shift to measuring *E. coli* or Enterococci.

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[14] Total Suspended Solids
[15] Mark Hicks, Ecology, Water Quality Program.
[16] Ibid.

Benefits may accrue to permitees in areas where the standards are relaxed. The benefits of delayed investment in additional chlorination or UV technology, and in chlorine and electricity will be linked in time with the costs. The benefits and costs only occur in the waters which already do, or which over time will have higher and higher rates of pernicious bacteria and viruses; and would only occur if the technological requirements were insufficient to reduce those rates. Technological requirements, however, are typically found to be very effective in removing bacterial indicators from wastewater, so minimal real-world opportunities for cost savings would be expected.

Time is an important but undetermined factor in this analysis. The estimates below are presented as of the time the benefits and costs begin accruing. However, the benefits of reduced effort on the part of the permitee and the additional exposures would begin and increase slowly over time as growth and investment decisions adjust under the new standard. Given this, it is not clear when the losses would begin. The analysis is presented as if it started immediately.

Ecology's proposed bacteria criteria, while less stringent than current standards for many waterbodies, is still more stringent than EPA's recommendations for what states should have. In adopting criteria to protect primary contact recreation waters, EPA recommends states and authorized tribes use enterococci and/or *E. coli* criteria with a specified illness rate no greater than 8 illnesses per 1000 swimmers for fresh waters and no greater than 19 illnesses per 1000 swimmers for marine waters. Ecology is proposing criteria to protect primary contact at 7 illnesses per 1000 swimmers for fresh water. In marine water, the criteria for shellfish results in very low illness rates for swimmers (probably less than 1 illness per 1000 swimmers). For the most part, Ecology's proposal is more protective than what EPA recommends as a minimum.

Nonetheless, Class AA waters and lakes are now more protected at an estimated illness rate of 4 illnesses per 1000. With the switch to use-based criteria, Ecology is proposing one primary contact criteria for all fresh waters of the state, at a rate of 7 illnesses per 1000. While this is still below EPA's recommended illness rates for states, and is thus more protective, the costs associated with the potentially increased illness rates going from 4 to 7 illnesses per 1000 creates a net cost in terms of increased cases of illnesses that far outweighs the benefits (as described in the following paragraphs).

Costs

Numbers of infections from the change in bacterial measurement

The bacterial test of water quality is used as an indicator of the existence of a variety of viruses, bacteria and parasites. The change in the rule reduces the stringency of the criteria, to at least a small degree, in most areas and may create an increase in recreational exposure to parasites, viruses and bacteria. See Appendix B for more information on viruses and parasites.

Citizens of the state participate in water based recreation regularly. The IOC[17] indicates that there were 3.7 million visitor days per year where direct facial exposure to water occurs and 8.7 million visitor days where direct facial exposure to water may occur. People swimming, wading, white-water rafting, diving, floating on inner tubes, or on jet-skis, generally get water in their eyes and mouths. The model assumes that 100% of people in this recreation category have contact. People who are in fishing or camping in boats or fishing from shore, may or may not get water in their eyes and mouths. In this latter category, it is more likely that children will approach the water. The model assumes that only 20% of people in this category have contact.

The number of visitor days in a given area is estimated based on the share of the waters in a category and the type of activity. For example Ecology included most freshwater recreation activities in the AA waters that are being converted to primary recreation and applied the activities to the 44% of the fresh waters in this category. However, Ecology did not include inner tubing and floating, jet skiing, or wind surfing because these activities are less likely to be done in the AA waters that are being converted to primary.

Whether or not the exposure occurs depends on the areas of recreation and any change in bacterial or viral load in that area.

Frequency of Illness Given Visitor Days

The rates of illness are extrapolated based on EPA's estimates of acute gastroenteritis per 1000 people participating in water based recreation.

Table 1

Freshwater			
	Illnesses per 1000 people	Conversion to *E. coli** from Fecal Coliform	Geometric Mean of Fecal Coliform
Current AA	4.02	47.5	50
Current A	6.85	95	100
Current B	9.68	190	200
	Illnesses per 1000 people	Geometric Mean of *E. coli*	
Proposed Primary Contact	7.06	100	
Proposed Secondary Contact	9.89	200	
*Ecology studies show that 90-100% of fecal coliform is *E. coli*			
Change in illness rate for fresh water			
AA --> Primary Contact	3.0		
A --> Primary Contact	0.2		
B --> Secondary Contact	0.2		

[17] Based on SCORP data from Interagency Committee for Outdoor Recreation, Jim Eyechaner, 12/26/02. Extrapolated based on 6 million population. SCORP data is in Appendix B.

For Fresh Water there will be a shift from a Fecal Coliform measure of exposure to an *E. coli* measure of exposure. Converting these measures causes a shift in the level of exposure. In addition, the new criteria for the current Class AA and A waters will now be the same and will be under the proposed Primary Contact for recreational waters. The new criteria for the current Class B waters will be the proposed Secondary Contact for recreational waters. In the current Class AA areas there will be an increase of 3 acute cases of gastroenteritis per 1,000 recreation days. For the current Class A and Class B waters there will be an increase of 2 acute cases of gastroenteritis per 10,000 recreation days.[18]

Table 2

Marine Water		
	Illnesses per 1000 people	Geometric Mean (of Fecal Coliform)
Current AA	<Shellfish>	14
Current A	<Shellfish>	14
Current B	15.33*	100
Current C	19*	200
	Illnesses per 1000 people	Geometric Mean
Proposed Primary Contact	<Shellfish>	14 fecal coliform
Proposed Secondary Contact	22.66	70 enterococci
* Approximations based on the following:		
The 1986 EPA guidance stated that the previous EPA criterion of fecal coliform at 200 cfu/100mL corresponds approximately 19 illnesses per 1000 swimmers.		
Therefore, the current Class C criterion risk rate is 19 illness per 1000 swimmers.		
The EPA proposed criteria of enterococci at 35 cfu/100mL was selected to also correspond to 19 illnesses per 1000 swimmers		
According the the 1986 EPA guidance, enterococci at 17.5 cfu/100 mL (1/2 the recommended criterion of 35) corresponds to 15.33 illnesses per 1000 swimmers		
The Class B criterion of fecal coliform of 100 cfu/100mL, is 1/2 of the previous EPA criterion of 200.		
Assuming that halving the fecal coliform criteria would have the same effect on illness rates as halving the enterococci criterion, the Class B criterion of fecal coliform at 100 cfu/100mL would also have an illness rate of 15.33 illness per 1000 swimmers.		

Change in illness rate for marine water	
AA --> Primary Contact	none
A --> Primary Contact	none
B --> Secondary Contact	7.3
C --> Secondary Contact	3.7

For salt or marine water there will only be a shift in areas where there are no shellfish. The shellfish areas will continue to be characterized by a Fecal Coliform indicator. In the current Class B there will be 7.3 additional exposures per 1000 visitor days and in the current Class C recreational areas there will be and additional 3.7 exposures per visitor day.

The rate of exposure may not change much in the short run because of institutional controls that are already in place for most treatment plants. From October 2000 to September 2001, the Department of Ecology's Environmental

[18] Andrew Kolosseus

Assessment Program collected bacteria samples at 85 sites. They collected twelve samples at most sites. *E. coli* is a subset of fecal coliform. In theory, the concentration of *E. coli* should always be less than the concentration of fecal coliform. The Department of Ecology's TMDL studies the last few years showed (and Metro King County's beach monitoring from 1998-2000 confirmed) that, on average, 90-100% of fecal coliform is *E. coli*. From these data, about 12% of rivers would have violated the proposed *E. coli* criterion.

Most of these rivers would therefore be directly affected by the proposed switch to *E. coli*. The allowed bacteria loads to most of these rivers would therefore be directly affected by the proposed switch to *E. coli*, which means that the risk of illness for people recreating in these rivers would increase. Over the next few years, the allowed bacteria loads to additional rivers may also be affected by the proposed switch to *E. coli*, which means the risks of illness for people recreating in these additional rivers would also increase. It would be reasonable to assume that besides the 12% waters that are proposed to not meet *E. coli* (as described above), another 12% of rivers would also be impacted negatively by *E. coli.* Predicting that the bacteria loads of a combined 24% of rivers would therefore be affected (and thus the risks of illness of people recreating in these rivers would be affected) either immediately or in the next few years by the proposed switch to *E. coli* seems a reasonable assumption. This 24% is the final multiplier, and reduces the number of illnesses caused by the change to *E. coli*.

The fresh water recreation activity would be expected to generate 983 added acute gastroenteritis cases. The salt water exposures would generate an additional 80 acute gastroenteritis cases.

Table 3

Shift in Illness Due to Bacterial Test				
	Probability	**Change in illness rate per 1000**	**Visitor Days**	**Number of added illnesses**
Freshwater	% River Miles [k]			
AA --> Primary Contact	44.00%	3.04	1,174,905	857
A --> Primary Contact	51.00%	0.21	2,357,291	119
B --> Secondary Contact	4.00%	0.21	147,175	7
Weighted average		**1.45**	3,679,370	983
Salt Water	% shoreline [k]			
B --> Secondary Contact	2.53%	7.33	44,953	79
C --> Secondary Contact	0.09%	3.66	1,546	1
Weighted average		**0.19**	46,499	80

In addition to acute cases that are identified through medical attention, there will be more moderate cases and subclinical cases. The moderate cases may involve lost work or school days but not medical care. The subclinical cases may not involve lost work or school days, but the individual may not function as well as usual while they fight of the infection. These moderate and subclinical cases are extrapolated from the acute cases.[19] The total annual estimated moderate and subclinical cases are 1,229 and 1,079 respectively. The number of rashes is

[19] The subclinical is based on: "Norwalk virus infection of volunteers: new insights based on improved assays," Graham DY, Jiang X, Tanaka T, Opekun AR, Madore HP, Estes MK, Journal of Infectious Disease, 1994 July: 170(1):34-43. Higher rates of 20 times the clinical cases are estimated for Shigella by the CDC: http://www.cdc.gov/ncidod/dbmd/diseaseinfo/shigellosis_g.htm#How do people catch Shigella.

estimated based on the share of shistosomes that generate reportable rashes relative to the number of gastroenteritis cases. This indicates there would be approximately 11 rashes per year.

Cost of illness

The cost of illness can be measured by changes in willingness to pay for quality of life (QUALY) changes or based on the direct cost of illness. The direct cost of illness includes only expenditures on medical care and foregone earnings. The QUALY literature places relative values on types of illness based on reduced quality of life for a period of time and based on our willingness to pay to avoid symptoms.

Table 4

Annual cost of infective and parasitic illness* **					
"Willingness to pay" QUALY basis****		Daily Value	Restricted Activity Days$^{\Omega}$	Dollars	
Mild food poisoning		$ 110	4.32	$ 476	
Severe food poisoning		$ 179	4.32	$ 774	
Severe rash		$ 110	2.29	$ 252	
Total annual value				$ 1,411,999	
Present Value of QUALY basis				$ 21,512,428	
Cost of Illness Basis***					
Per case medical expenditures^^				$ 266	
Per case foregone earnings				$ 112	
Per case losses					
Total annual value				$ 941,993	
Present Value of Cost of Illness basis				$ 14,351,677	

Ecology selected mild and severe food poisoning for the basis for gastroenteritis costs for the QUALY literature.[20] The gastroenteritis for food poisoning is accomplished by essentially the same set of illnesses that generate waterborne exposure. Mild food poisoning is valued at $476 per case and severe food poisoning is valued at $774 per case. Although there are costs associated with mild illnesses, which never-the-less allow the person to go to work, no value was assigned for subclinical gastroenteritis. Rashes are valued at $252 per case. The value using the QUALY basis is $1.4 million per year.

Cost of illness can also be valued based on medical expenditures ($266 per case)[21] and foregone earnings ($112 per day).[22] Severe gastroenteritis and rashes are expected to generate both medical costs and foregone earnings. Moderate gastroenteritis is expected to generate only foregone earnings. Sub-clinical gastroenteritis certainly generates costs but no cost is assigned. The total annual cost of illness basis using only direct costs is $942,000.

The total expected present value of new illness ranges from $14 to $21 million.[23]

[20] Valuing Health for Policy: an economic approach, George Tolley, Donald Kenkel, and Robert Fabian, University of Chicago Press, 1994, Table 15.2, pg. 330
[21] Average gastroenteritis and salmonella costs for 49 cases covered by the Washington State Health Care Authority.
[22] Valuing Health for Policy: an economic approach, George Tolley, Donald Kenkel, and Robert Fabian, University of Chicago Press, 1994, Table 3.3, pg. 65.
[23] Present value is calculated based on a 3% discount rate.

Note: These costs do not include the value of illness for tourists and visitors, who are not Washington citizens and are therefore not included in the SCORP.[24]

Laboratory Costs

All freshwater facilities and some salt water facilities that currently do fecal coliform testing will be affected. The cost of shifting from a fecal coliform test to either an *E. coli* test or an enterococci test is a function of the number of tests and the difference in the cost per test. The cost of the test is based, for consistency, on the relative cost of a membrane filter test for fecal coliform ($20), *E. coli* ($29) and enterococci ($29).[25] This cost estimate may overstate the cost because many facilities do their own testing and because as it becomes the dominant test, the cost per unit may go down.[26]

Facilities on fresh water will be shifting from fecal coliform to *E. coli.* Facilities on salt water will shift from fecal coliform to enterococci unless they are near a shellfish bed, in which case there is no change.

Each facility has a different testing regimen, generally ranging from 1 test every 2 weeks to daily testing. For the random sample of facilities the number of tests required for each facility was used to calculate the 20 year present value of the cost of shifting to the new test for that facility.[27] These costs were extrapolated to the unsampled facilities based on the type of water which they discharge to.

The total cost of the shift to a new lab test, extrapolated over a 20 year period is approximately $3.6 million.

Benefits

The new standards will probably not affect municipal permit compliance for limits on coliform bacteria. Currently, most municipals have an effluent limit of 200 colonies/100 ml. This limit is technology-based (a treatment plant with a properly operated disinfection system can meet this limit). A water quality-based limit (based on dilution in the receiving water) for most facilities would be higher than 200 colonies/100ml.[28]

E. *coli* and enterococci are more reliable indicators than fecal coliform. Sometimes fecal coliform may overestimate actual risk of illness. Fecal coliform testing can enumerate *Klebsiellae* and thus could possibly overstate health risks, particularly of bathing in waters with a high wood waste component. While *E. coli* is a subset of fecal coliform, fecal coliform and

[24] A State Comprehensive Outdoor Recreation Planning Document, An Assessment of Outdoor Recreation in Washington State, Interagency Committee for Outdoor Recreation, October 2002.
[25] Estimated cost shift for bacteria based on Manchester Lab bids: PDF file Price List 10_99.pdf
[26] Gary Bailey, Water Quality Program.
[27] A 3% discount rate was used to obtain the present value.
[28] Gary Bailey, Department of Ecology, 3/27/03.

enterococci are very different measures. It would be good to be able to have the greater certainty that *E. coli* and enterococci provide.

Cost Benefit Analysis for Dissolved Oxygen and Temperature Standards

Numeric criteria for temperature and dissolved oxygen criteria do not exist in either state or federal law. However, there are guiding demands that exist that help define what the objectives are expected to be in setting criteria to protect Washington's waters.

Net Benefits

The net impact of the dissolved oxygen and temperature changes is unclear. The cost analysis is extremely sensitive to whether permits are affected and the range is large. The cost estimate ranges from $13 million to $45 million statewide.

Benefits are not quantified but if fish populations are sufficiently increased in a given waterbody, the benefits are potentially much larger than the costs. However most permits will not be affected and some of these benefits may not accrue.

The possible property benefits are small, ranging from -$50,000 to +$1.9 million. Further these values probably include the fish values and bacterial losses evaluated elsewhere.

The number of facilities affected

There is a high degree of uncertainty as to how many facilities will be affected. From 12 to 26 facilities may be affected. Estimating the number of occurrences of an infrequent event for a population always generates a small numbers problem. Even with a relatively large sample size, very few facilities were identified. If the sample includes one extra affected facility then the estimated percentage of facilities increases substantially. Further, estimating the cost of an impact, when it is unclear which facilities will affected by each standard, means that the range of costs must be probabilistically generated based on the distribution of facility discharge data.

Ecology sampled facilities based on the change to the use based water quality standard. Most facilities are shifting from either Class AA or Class A into the Salmon Spawning Use. Both of these shifts were given a sample of 35. The sample included a total of 19% of all the facilities and was intended to cover all sections of the major rule changes: Bacterial, Agricultural Standards, and Temperature and Dissolved Oxygen.

Table 5

Change from Class to Use Base	Cases	Sample
Class B, Salmon Rearing	20	9
Class AA, Salmon Spawning	105	35
Class AA, Char	2	2
Class A, Salmon Spawning	301	35
Class A, Char	1	1
	429	82

The small numbers problem asserts itself in that, with a sample of 35, one facility is interpreted to represent 2.9% of the entire population. In other words, if a facility in the sample is affected, Ecology would then assume that facility represents 2.9% of that particular population.

The small numbers problem was exacerbated by uncertainty regarding whether facilities were affected. Permit writers were asked about their facilities. The interviewer used the following list of screening questions to try to determine whether there was a status change for a given facility. In no case, which was selected as possibly being affected, was the staff member certain that there would be an impact.

Table 6

List of Screening Questions
1. Does the receiving water for this facility currently meet the standard?
2. Will the receiving water for this facility meet the new standard?
3. If the answers above differ, will the facility need or be allowed to change what it is doing?
4. If the answer above is yes, will it save them or cost them money?

Often there is no information available on the local temperature or dissolved oxygen of the receiving water itself so questions 1 and 2 had to be answered based on samples from some distance above or below the receiving water. This introduced great uncertainty in most instances. During different discussions, the answers changed for a specific facility. In other instances the answer was immediately clear; however, usually this meant that there was already an existing problem based on the current standard. For dissolved oxygen the answers were particularly difficult as the sag due to biological oxygen demand from both upstream facilities and the sampled facility expresses itself in different places due to rate of flow and turbulence shifts. For temperature, it was sometimes easier because if all the tributaries to a reach are thought to exceed a standard in the summer time, then it is likely that the receiving water also does.

Given the uncertainty, sensitivity testing was essential. The frequency of impacts is bounded based on assuming that there would be one more or one less facility affected in each of the sub-samples.[29] The estimated cost impact of the rule was highly sensitive to a single case shift. Staff therefore attempted to adjust for this problem by assigning a probability to cases subject to a high

[29] There was no need for sensitivity testing for A to Char or AA to Char because all the facilities were in the sample.

degree of uncertainty. What this means is that cases were assigned a probability of being affected: if a permit writer felt that the permit was less likely than likely to be affected it was assigned a probability of .2. These probabilities were also attached to a probabilistic distribution for sensitivity testing. Probabilities were assigned for both Dissolved Oxygen and temperature. Permits with relatively clear impacts or lack of impact were assigned a probability of one or a zero. The estimated cost impact is also sensitive to the probability estimate.

The cost to the affected facilities was based on 3 cases from the private sector and on data provided by an equipment provider. The provider data provides a cost curve that is a nonlinear function of the maximum facility flow data.

The total cost estimate is a simple multiplicative function of the size of flow, the probability that a facility will be affected and the cost of that flow.

What this means is that Ecology does not really know the cost of the rule to permitees. Staff has given a range of possible costs but it is a range driven by a subjective estimate of probabilities, a single case shift driver and a cost per unit of flow function.

Estimating the Costs

The statewide estimated total facility cost of the proposed rule changes for dissolved oxygen and temperature ranges from $13[30] to $45 million. This is based on the estimated frequency of a permit being affected, multiplied by an average expected cost, given the flow of the facility. Most of the range is generated by sensitivity testing regarding the number of permits being affected.

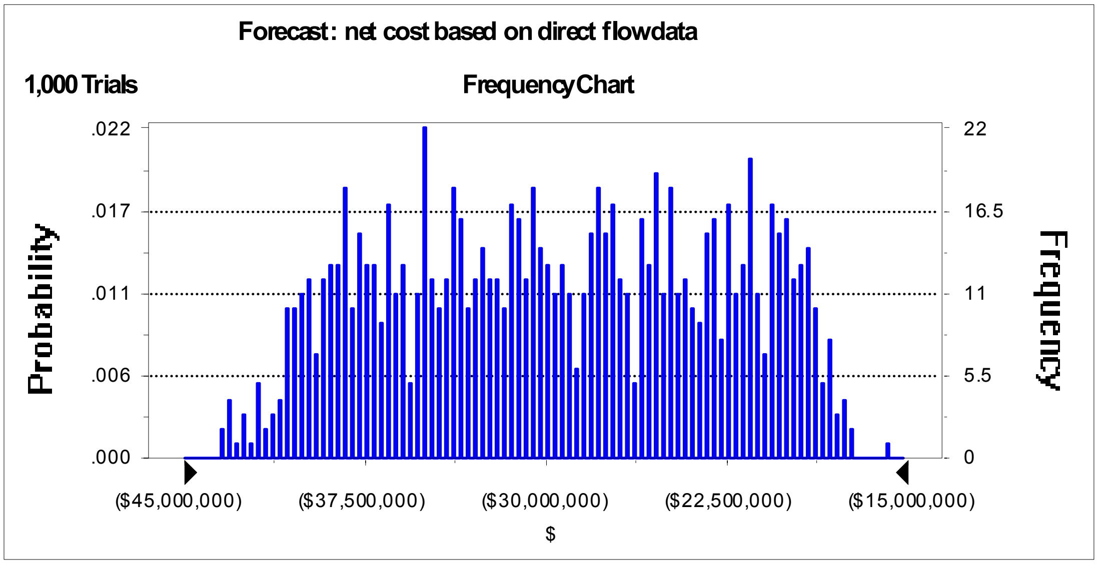
The formula that feeds into this is the **sum for all facilities** of the estimated cost based on:

The **flow** through each facility based on expected maximum daily flow
x the **probability** that a facility in this class will be affected by the rule given the survey results and given sensitivity testing
x the **average cost** based on cooling tower costs, stream or wetland modifications, <u>and granulated media filters.</u>

= **Average cost for the type of facility given the flow**

[30] The lower bound is a direct extrapolation from costs in the sample rather than the cost adjusted by actual flows from all facilities. The latter lower bound would be $15 million.

Graph 2



Costs or gains for an individual facility

The cost or gain for an individual facility depends on whether the rule will affect the facility at all, the flow from the facility, and what the facility management decides to do to meet the standard. In places where the standard becomes more stringent, the facility may experience costs from a new installation of technology or treatment. In places where the standard becomes less stringent, the facility may experience gains from being able to postpone or avoid an installation.

Note: for each type of action below Ecology has limited data and would like to receive data on recent installations.

The flow from each facility was attached to a cost function and then was multiplied by the probability[31] that the facility would be affected. The facility data on the flow is defined based on the expected maximum daily flow. In most cases this is the correct flow. However, these maximum daily flows may be affected by an accident or problem that is temporary and which would not affect the design flow for meeting the standards. Thus the flow that feeds into the equation may be higher than necessary. For some facilities this generates higher costs estimates than those the facilities would actually experience.

The costs of actions taken to meet the standard depend on what method the facility management decides to pursue.

Temperature and Dissolved Oxygen changes together:

[31] The probability is extrapolated from the survey and is allowed to vary for sensitivity testing.

- Cooling towers: Cooling towers (see cost below under temperature) that expose water directly to the air also add oxygen and boost DO. If the problem is the DO in the effluent and not the BOD, this kind of cooling tower may address both problems.

- Stream or Wetland Restoration: Passing water through a restored, shaded meander can cool the water, increase DO, and remove BOD. This may not be possible for every facility since it requires that sufficient suitable space be available. Data from one restoration project that handles 1.5 million gallons per day provides a construction cost of $444,000, consulting costs of $66,000 and costs approximately $.34 per gallon per day of capacity. Any given facility considering this kind of project would have to add land value to this cost. In some areas of the state this cost is very low and in others very high. Thus, depending on the facility, it could be either the cheapest or the most expensive of options.

- Ponds and lagoons that hold water for sufficient periods of time to allow cooling, increases in dissolved oxygen and reductions in BOD. This mechanism is discussed under temperature.

Temperature changes:

- Several mechanisms exist for cooling down water that is either hot or warm to the limit prescribed in a permit.

- Cooling Towers: Cooling towers can reduce the temperature of water to dew point. A recently built cooling tower, which handles 1 million gallons per day, cost $750,000 to build, maintenance costs are estimated at $45,000[32] per year, and running costs are estimated at $25 per day. The 20 year present value of the costs is estimated at $1.7 million[33] or $1.68 per gallon per day of capacity.

- Ponds with early morning release: Ponds can be constructed for holding water for later release. The water can be allowed to cool during the night and released in the morning. Alternatively, placement of the intake pipe for the released water can affect the temperature of the water leaving the pond. Shading assists in cooling. The cost of a lagoon or pond ranges from an extreme low of $.26 per gallon[34] to a more likely range of between $.62 and $1.40 per gallon of capacity.[35] Land costs will have a large impact on the costs. The duration that the water must be kept to reach the desired temperature will drive the size of the facility.

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[32] Estimate based on 6% of capital costs.
[33] Based on a rate of 1.6%, inflation free government bonds.
[34] Structured estimate of lined cooling pond only.
[35] Swine Facility Cost in Iowa, J. D. Harmon, www.extension.iastate.edu/Pages/ansci/swinereports/asl-1388.pdf.

- Adding through put: Non-contact cooling water used to cool industrial processes may be too hot for release. Additional water can be used to dilute this heat effect. The cost of the water to society ranges from $21 per acre foot to $1,419 depending on its use.[36]

Dissolved Oxygen Changes:

- In addition to the mechanisms above, granulated media filters can reduce the biological oxygen demand. One case recently constructed to handle 1.3 million gallons per day cost $640,000 to build. Ecology estimated the maintenance and power costs of this facility at about $47,000. The estimated cost per gallon per day of capacity is $.83. An equipment supplier checked on their client's cost experience. On a per gallon per day of capacity for costs of installation and maintenance was $.17 for a 17 million gallon per day, $.21 for 4.3 million gallons per day, $.37 for 1.3 million gallons per day, and $.33 for .5 million gallons per day.[37]

Biases introduced by survey method

Ecology resurveyed permit writers regarding facilities that appeared to have impacts. This created directional bias that probably understates costs. Sensitivity testing indicates that any bias would create a problem and thus the ranges on the potential costs are large. However, there is no other data available on the frequency of cost impacts on the facilities.

Estimating the Benefits

The estimated benefits for this rule amendment are based on fish population impacts and property value impacts.

- Fish: Numerous surveys and revealed preference studies have indicated that people are willing to pay for fish.
- Property: Several studies indicate that people are willing to pay more for residential land that has higher water quality.

[36] Frederick, Kenneth D, Tim VandenBerg, Jean Hanson, 1996, Economic Values of Freshwater in the United States, Discussion Paper 97-03, Resources for the Future.
Ayer, Harry W., 1983a, "Crop Water Production Functions: Economic Implications for Washington." USDA ERS Report No. AGES-830314, Washington, D.C. (Study 13)
Ayer, Harry W., 1983b, "Crop Water Production Functions for Potatoes and Dry Beans in Idaho." USDA ERS Report No. AGES-830302, Washington, D.C. (Study 13)
Washington State University, 1972, "Irrigation Development Potential and Economic Impacts Related to Water Use in the Yakima River Basin." Paper for the Yakima Valley Natural Resources Development Association. (Study number 23)
Study numbering system from the Frederick paper.
[37] Based on a 20 year scenario. Raw data from USFilter.

- Shorelines: Ecology recently conducted a survey of willingness to pay for shoreline protection, one of the benefits of which was water quality. The positive result for this survey is an added indication of continuing value for environmental quality.[38]

Fish Populations

Fish are valued by people and are essential to the ecosystem. Their value in some uses is very high, and if the proposed rule amendment increased fish populations, the benefit would be very large by comparison with the costs. However, Ecology does not have the ability to define with certainty the impact of this rule on fish populations. Some fish populations will benefit. Other fish populations will not. This analysis cannot give a value other than to describe the qualitative values that might accrue if the fish populations were substantially increased.

Changes in the Fish Population

The potential size and health of fish populations are affected by the water temperatures and dissolved oxygen concentrations experienced by the fish at different stages of their development. The purpose of this analysis is to use the knowledge gained in the process of reviewing and recommending changes to Washington's water quality criteria to assess the potential effects of the proposed changes to fish populations.

Direct acute mortality to juvenile and adult fish would be avoided under both the current and proposed change to the water quality criteria for temperature and dissolved oxygen. The changes in health and ultimate survival discussed herein are related to risks of loss due to warm water diseases, reduced maximum size under natural stream conditions, interference with the ability to compete with warm water tolerant species, impairment of the fecundity of ripe adult fish, and impairment of the ability of juvenile fish to smolt and enter sea water. While quantitative estimates could be roughly made at a site-specific level after considerable study, the extreme variability in the factors that affect fish populations creates an unacceptable amount of uncertainty for making statewide predictions. The following information therefore describes qualitatively how the various physical and biological factors combine to create a biological response to changes in the state's water quality criteria. A critical point is that imperfect knowledge and high known levels of variability make a quantitative assessment on the impact to fish populations too problematic to attempt. No reasonable range of effects can be estimated quantitatively at this time.

Changes in statewide criteria are being proposed for five situations where the existing waters will be changed from a class of protection to a specific aquatic life use for protection:

1. Class AA waters that will change to char spawning and rearing;
2. Class AA waters that will change to salmon and trout spawning and rearing;
3. Class A waters that will change to char spawning and rearing;

[38] Survey of Washington Households on the Shoreline Management Act and Related Shoreline Issues, July 1996. Washington State Department of Ecology.

4. Class A waters that will change to salmon and trout spawning and rearing; and
5. Class B waters that will change to salmon and trout rearing-only.

To quantitatively assess the effect of changing temperatures, the specific patterns of the relationship between fish populations and their pattern of stream use in specific waters and the annual and interannual temporal patterns of temperature must be known.

Some of what we <u>do not</u> know in sufficient detail includes:

- the number of streams in each of the existing classes (Class AA, A, and B)
- the number of streams in each class that meet the current water quality criteria
- the number of streams in each class that can meet the proposed criteria
- the number of streams in each class with summer spawning fish populations
- the number of fish of each species and stock in each stream
- the number of fish in each spawning population and where it actually spawns
- the number of adult fish with mature (ripe) eggs during the peak of summer
- the timeframes over which each fish run spawns, the proportions of fish that spawn as time progress, and the accompanying temperature changes
- the limitations imposed by the presence of multiple water quality factors such as temperature, sedimentation, oxygen, flows, and toxics
- the long-term continental and oceanic patterns of climate
- the extent of ocean harvest by humans and natural predation on individual stocks

Problems in quantitatively modeling the effect of the proposed changes also comes from the high variability that occurs where we do have data or specific knowledge.

Some examples of extreme variability that make predictions problematic include:

- fish runs vary greatly in size from less than 200 to greater than 12,000
- the number of eggs deposited by female fish can range from under 2,000 to as much as 7,000, depending upon the specific species and sizes of the fish
- the survival rates of the eggs in the gravels commonly ranges from below 35% to as much as 90%, depending upon the fertilization, substrate, flow, and oxygen, temperature, disease, and predation patterns
- survival from fry to returning adults commonly ranges from 0.01 to 25%, depending upon the year, the species and stock, and the location of the natal stream

Even though a model can be created that does a respectable job of intertwining all of the environmental and biological factors *conceptually*, the prediction that results from using the model creates ranges of effects that encompass several orders of magnitude. In essence it can be said that even where all the right factors are considered the result is likely not to be a sound prediction of the changes to fish populations. The general biological risks of one criteria versus another, however, can be discussed. This information has already been provided in formal science-review discussion papers released by Ecology as part of the 2003 rulemaking on surface water standards (<u>Evaluating Standards for Protecting Aquatic Life in Washington's Surface Water Quality Standards, Temperature Criteria, Draft Discussion Paper and Literature Summary</u>, December 2002 Pub. Number 00-10-070; and <u>Evaluating Standards for Protecting Aquatic Life</u>

in Washington's Surface Water Quality Standards, Dissolved Oxygen Criteria, Draft Discussion Paper and Literature Summary, December 2002 Pub. Number 00-10-071).

General Overview and Assessment of Effects

Populations with the Most to Gain or Lose:

One way to get a relative sense of the number of fish that may be effected by changing the state standards is to focus on the most vulnerable fish populations. These would seem to include areas where native char spawn and spend their first year of juvenile life, and include streams that are used into the summer for spawning and incubation by salmon and trout.

Washington Department of Fish and Wildlife SASSI (Salmon and Steelhead Stock Inventory) data base was used to obtain the number of streams having summer spawning stocks that are currently in each class of waters:

Table 7

Transformation to Proposed Use Type	**# of July-August Spawning Stocks**
Class AA to char use type	189
Class AA to spawning and rearing use type	289
Class A to char use type	7
Class A to spawning and rearing use type	139
Class B to salmon and trout rearing-only use type	0

Not all of the streams will be capable of benefiting from a change in water quality criteria. Some streams will be naturally warmer than either or both the existing and proposed criteria. While some streams will be able to improve from existing poor conditions to being able to meet the proposed criteria, others will not. And still others may not be improved as much as they are capable of, if a less restrictive criterion is proposed. The only area where it is relatively clear that fish will be affected is where the existing criteria are being met. But even here, the level of ground water input and the location and land status (e.g., wilderness areas) make it so that some streams which meet the current standards really won't be warmed up in response to changing temperature criteria. The following table shows the relative level of attainment with the existing criteria for oxygen and temperature based on a review of approximately 140 ambient stations (Hallock, 2003). While such information helps assess the relative fact that many individual stocks may be harmed if summer temperatures increase, or benefit if they are decreased, it still cannot answer the question of how many streams may fully capture the effect of changing the state criteria:

Table 8

	Temperature					Oxygen			
	AA	A	B	Total		AA	A	B	Total
Total Stations sampled	30	108	5	143		29	107	5	141
No. of station exceeding criteria	10	63	4	77		15	28	0	43
Percent of stations exceeding	33%	58%	80%	53%		52%	26%	0%	30%

The proposed addition of char spawning and early tributary rearing protection to the state standards is another area noted above as having significant benefits. Population numbers for these char are not available, so one indirect way to assess the relative benefit of establishing revised criteria to protect char is to assess the proportion of streams affected. Since this is also true of the general protections afforded other fish and aquatic life, the following table shows the proportion of waters in each use-type:

Table 9

Breakdown of Streams in Washington by Use and Class (in miles)				
	Char Spawn	**Spawn & Rear**	**Rearing**	**Grand Total**
Class AA	10,270	24,636	0	**34,906**
Class A	826	37,379	0	**38,204**
Class B	0	0	3,652	**3,652**
Grand Total	**11,096**	**62,015**	**3,652**	**76,762**

Summary of Biological Consequences:

While it is not possible to predict how changing the state standards will quantitatively impact fish populations in Washington, it is possible to describe how the general levels of protection will change:

Temperature:

Table 10

Transformation to Proposed Use Type	Change in Biological Effect
Class AA to char use type	This proposed change will on average result in a 2°C reduction in allowable summer temperatures in waters assigned the proposed 13°C 7DADMax criteria. The existing criteria (1-DMax 16°C) is well outside the range that will protect spawning or early tributary rearing for char. The proposed criteria (7-DADMax 13°C) is at the upper end of what will fully protect the early rearing of char, and will meet spawning needs with minimal fall cooling (spawning initiation requires temperatures below 9°C). The proposed criteria also fully protects all life-stages of trout and salmon, and protects the most sensitive summer spawning stocks. **Thus this change results in important benefits to fish populations in general, and is critical to the long term health of char species.**
Class AA to spawning and rearing use type	This proposed change will on average result in a 1°C increase in allowable summer temperatures in waters assigned the proposed 16°C 7DADMax criteria (existing criteria on average equals a 7DADMax of 15°C). To avoid prespawning losses of eggs, the highest 7DADMax temperature should not exceed 13.5-15°C in the week or two immediately prior to spawning. The existing Class AA criteria is a 1-day maximum of 16°C. On average this would be equal to a 7DADMax criteria of 15°C, thus would be unlikely to cause a measurable loss in potential offspring due to effects on ripe eggs. The proposed 7DADMax temperature of 16°C would be estimated to potentially result in a 13% loss of eggs in ripe hen salmon. To virtually eliminate the risk of losses from warm water diseases, water temperatures would need to be below a 7DADMax of 12.6-16.2°C (14.38°C is considered the best estimate for a threshold for this level of effect). To avoid serious rates of infection and mortality the 7DADMax would need to be below 15.6-19.2°C (17.38°C is considered the best estimate for a threshold for this level of effect). To prevent severe rates of infection and catastrophic outbreaks the 7DADMax temperature would need to be below 18.6-23.2°C (20.88°C is considered the best estimate for a threshold for this level of effect). The existing Class AA temperature criteria is approximately equal to a 7DADMax of 15°C and the proposed change in temperature criteria would increase the target criteria to a 7DADMax of 16°C. A 7DADMax of 16°C

	has the potential to completely eliminate losses associated with warm water diseases. It is at the upper end of the probable range for the risk of warm water disease and is essentially at the lower end of the probable range for temperatures that would be associated with serious rates of infection and mortality. A 7DADMax temperature of 15°C is well within the probable range for temperatures that would eliminate warmwater disease effects thus the proposed criteria would create some unspecifiable added margin of potential protection. The protection of incubating eggs and developing embryos is best described by having 7DADMax temperature below 12.5-14.0°C (median 13.2°C) at the time of fertilization for fall spawning stocks and by the point of emergence from the gravels for spring spawning stocks. Keeping lower summer temperatures (the existing 1-day maximum of 16°C versus the proposed 7DADMax of 16°C) would be expected to better protect spring and summer incubating stocks. Based on the evaluation of temperature data collected in Washington, 42% of the assessed streams would not meet 13°C at the time of spawning initiation in the fall if using the *existing* Class AA criteria (an average 7DADMax of 15°C) and 68% would not meet 13°C at the appropriate time using the *proposed* criteria (a 7DADMax 16°C). Thus the potential reduction in fish in response to increasing the criteria from an approximate 7DADMax of 15°C to a 7DADMax of 16°C may be estimated using the relative difference of 26%. To protect the smoltification capability of juvenile salmonids, the 7DADMax temperatures should not exceed 15.2-16.2°C prior to or in the early stages of out-migration. It is estimated that a 7DADMax of 18-19°C may prevent or stop smoltification entirely. Since many of the state's Class AA waters are used by the juvenile fish for rearing in preparation for their eventual seaward migration, this potential effect may be influenced by the proposed change in temperature criteria. Both the existing criteria of 15°C and the proposed criteria of 16°C fall within range of the estimate of temperatures that prevent any interference with out-migration. Therefore, while there is a slight increase risk of interference related to the proposed criteria being at the upper range of the estimated safe temperature regime, it is not amenable to estimation of potential risks in fish populations. **Thus with the exception of summer spawning stocks, the proposed criteria is not materially posing any change in the health of fish populations.**
Class A to char use type	The existing criteria (1-DMax 18°C) is well outside the range that will protect spawning or early tributary rearing for char. The proposed criteria (7-DADMax 13°C) is at the upper end of what will fully protect the early

	rearing of char, and will meet spawning needs with minimal fall cooling. The proposed criteria also fully protects all life-stages of trout and salmon, and protects the most sensitive summer spawning stocks. **Thus this change results in important benefits to fish populations in general, and is critical to the long term health of char species.**
Class A to spawning and rearing use type	Class A freshwater criteria will change from a one-day maximum temperature of 18°C to a 7-day average of daily maximum temperatures of 16°C. Based on a review of existing state water temperature data, a 7-DADMax of 16°C is on average equal to a one-day maximum temperature of 17°C. So in essence, the change is a 1°C reduction in temperature from a 7-DADMax of 17°C to 16°C. To virtually eliminate the risk of losses from warm water diseases, water temperatures would need to be below a 7DADMax of 12.6-16.2°C (14.38°C is considered the best estimate for a threshold for this level of effect). To avoid serious rates of infection and mortality the 7DADMax would need to be below 15.6-19.2°C (17.38°C is considered the best estimate for a threshold for this level of effect). To prevent severe rates of infection and catastrophic outbreaks the 7DADMax temperature would need to be below 18.6-23.2°C (20.88°C is considered the best estimate for a threshold for this level of effect). The existing Class A temperature criteria is approximately equal to a 7DADMax of 17°C and the proposed change in temperature criteria would lower the target criteria to a 7DADMax of 16°C. A 7DADMax of 16°C has the potential to completely eliminate losses associated with warm water diseases. It is at the upper end of the probable range for the risk of warm water disease and is essentially at the lower end of the probable range for temperatures that would be associated with serious rates of infection and mortality. A 7DADMax temperature of 17°C is completely outside the probable range for temperatures that would eliminate warmwater disease effects, and thus would have a high probability of allowing for some losses due to infections. The 7DADMax of 17°C closely aligns with the best estimate for a threshold criteria to avoid serious rates of infection and mortality. Thus the conclusion is that decreasing the summer 7DADMax from 17°C to 16°C will prevent moderate rates of infection and mortality that would otherwise occur at the existing Class A temperature criteria. It may even be enough of a change to stop all losses due to warm water diseases in some waters. Moderate mortalities in association with this estimate would be described as typical losses of 20-60%. Using the results from nine independent lines of evidence pertaining to juvenile rearing health, a healthy summer rearing temperature would be described as occurring within the range of 14.8-18.1°C with the median estimate of 16.5°C as a 7DADMax temperature having the highest probability of representing the best estimate. Since 16.5°C essentially falls

	between the current and the proposed criteria (17 and 16°C, respectively) there is unlikely to be any improvement in size or condition in response to the proposed change. Cool water and warm water species may displace and prey on coldwater species at excessive levels at warmer stream temperatures. It is estimated that as the 7DADMax temperature exceeds 17.6-18.1°C (median 17.89°C) coldwater species may begin to be displaced from the best habitats for feeding. The proposed criteria change would reduce the allowable temperature from an average 7DADMax of 17°C to a 7DADMax of 16°C. Neither of these temperatures would clearly change the competitive relationship with salmon and trout and their warmer water loving competitors, however, the proposed temperature of 16°C would be much less likely to allow for predatory advantages in salmonid and trout habitat since salmonids would still be at their healthiest condition. To avoid prespawning losses of eggs the highest 7DADMax temperature should not exceed 13.5-15°C in the week or two immediately prior to spawning. High prespawning losses would be expected where 7DADMax temperatures are greater than 15.5-16°C just prior to spawning. Where spawning occurs at or during the summer peak temperature period, the proposed change from a estimated 7DADMax of 17°C to a 7DADMax of 16°C would be estimated to prevent significant prespawning losses of potentially viable eggs. Temperatures (7DADMax) of 13.5-15°C are associated with the general absence of expected egg losses, and temperatures 1-2°C above this range are associated with moderate (13%) to high (45-50%) losses to eggs in ripe adults. For the purpose of assessing the difference between the existing and proposed temperature criteria, the effect of lowering the water temperature may be best represented by the difference between the moderate and high egg loss rates. Thus as much as 32-37% of a loss in egg viability may be prevented by maintaining ripe adults at a 7DADMax of 16°C compared to 17°C just prior to spawning. The protection of incubating eggs and developing embryos is best described by having 7DADMax temperatures below 12.5-14.0°C (median 13.2°C) at the time of fertilization for summer to fall spawning stocks and by the point of emergence from the gravels for spring spawning stocks. Keeping lower summer temperatures (the proposed 7DADMax of 16°C versus the existing average 17°C) would be expected to better protect spring and summer incubating stocks. While moderate temperatures may help them grow to sufficient size in a shorter period of time, water temperatures that are too warm can impair the ability of the smolts to live in salt water or can prevent their migration altogether. To protect the smoltification capability of juvenile salmonids, the 7DADMax temperatures should not exceed 15.2-16.2°C prior to or in

	the early stages of out-migration. It is estimated that a 7DADMax of 18-19°C may prevent or stop smoltification entirely. Since many of the state's Class A waters are used by the juvenile fish for rearing in preparation for their eventual seaward migration, this potential effect may be influenced by the proposed change in temperature criteria. **Thus the proposed criteria brings temperatures into a range that fully protects outmigrating smolts and prevents potentially moderate losses from warmwater diseases. The proposed criteria would also reduce the level of potential prespawning and post-spawning losses compared to the existing criteria.**
Class B to salmon and trout rearing-only use type	For those Class B waters the criteria is proposed to change from a single daily maximum temperature of 21°C to a 7-day average of the daily maximum temperatures of 17.5°C. A 1-day maximum temperature of 21°C would on average be equal to a 7-day average daily maximum of 20°C. So, on average the change from Class B to rearing protection would result in a 2.5°C reduction in the allowable temperature for these rivers. To virtually eliminate the risk of loss from warm water diseases, water temperatures would need to be below a 7DADMax of 12.6-16.2°C (14.38°C is considered the best estimate for a threshold for this level of effect). To avoid serious rates of infection and mortality the 7DADMax would need to be below 15.6-19.2°C (17.38°C is considered the best estimate for a threshold for this level of effect). To prevent severe rates of infection and catastrophic outbreaks the 7DADMax temperature would need to be below 18.6-23.2°C (20.88°C is considered the best estimate for a threshold for this level of effect). The existing Class B temperature criteria is approximately equal to a 7DADMax of 20°C and the proposed change in temperature criteria would lower the target criteria to a 7DADMax of 17.5°C. A 7DADMax of 20°C is 1.4°C above the lower end of the range of temperatures predicted to allow for catastrophic outbreaks of warm water disease (18.6-23.2°C). The proposed criteria (7DADMax of 17.5°C) would be in a range that would be associated with a good chance of serious rates of infection. Thus, the conclusion is that decreasing the summer 7DADMax from approximately 20°C to 17.5°C will prevent catastrophic rates of infection and mortality that may otherwise be possible at the existing Class B temperature criteria. Moderate mortalities in association with this estimate would be described as typical losses of 20-60%. Catastrophic effects would be described as losses in the range of 60-100% in those infected populations. It is therefore assumed that the change from a 7DADMax of 20°C to one at 17.5°C may in some rivers and stocks prevent losses as much as 40-80%, the difference in losses between serious and catastrophic rates of infections. Using the results from nine independent lines of evidence pertaining to

	juvenile rearing health, a healthy summer rearing temperature would be described as occurring within the range of 14.8-18.1°C with the median estimate of 16.5°C as a 7DADMax temperature having the highest probability of representing the best estimate. Data is not available to estimate the effect on fish size from reducing summer temperatures to 17.5-18°C, however, this change would move the criteria into the range of healthy growth. It is estimated that as the 7DADMax temperature exceeds 17.6-18.1°C (median 17.89°C) coldwater species may begin to be displaced from the best habitats for feeding. The proposed criteria change would reduce the allowable temperature from an average 7DADMax of 19°C to a 7DADMax of 17.5-18°C. The existing criteria is 1-1.5°C above the level determined to prevent excessive competition between salmon and trout and their warmer water loving competitors. Thus the proposed temperature would be much less likely to allow for predatory advantages in salmonid and trout habitat since salmonids would still be at their healthiest condition. Based on the technical literature it would be reasonable to assume that competition may result in up to a 20% reduction in growth production and if temperature remain near the existing criteria for much of the summer the displacement of salmonids from the best rearing/feeding habitats. Some of the displaced fish would be expected to be lost from the system due to crowding and intra-species competition in the remaining available habitat. Mean daily maximum temperatures of only 1°C higher than the existing Class B criteria have been associated with 50% reduction in production and serious restrictions in the distribution of salmonids. To protect the smoltification capability of juvenile salmonids, the 7DADMax temperatures should not exceed 15.2-16.2°C prior to or in the early stages of out-migration. It is estimated that a 7DADMax of 18-19°C may prevent or stop smoltification entirely. It is important to note that neither the existing nor the proposed criteria would be considered fully protective in waterways where juvenile fish are not fully underway with their physiological adaptations and migrations prior to encountering the temperatures permitted currently in Class B waters. **Thus the change in criteria would bring the allowable temperatures below the range identified as potentially causing catastrophic losses to warmwater disease, cessation of out-migration in smolts, and displacement by warm water competitors.**

Dissolved Oxygen:

Table 11

Transformation to Proposed Use Type	Change in Biological Effect
Class AA to salmonid spawning and rearing use type	The criteria would change from a single daily minimum of 9.5 mg/l to a 90-day average of the daily minimums of 9.5 with no single day less than 7.0 mg/l. On average the proposed criteria represents a 1 mg/l reduction in protection for dissolved oxygen. Adequate oxygen levels are critical to the health of incubating salmon eggs and larvae. A mean concentration of 9 mg/l is the lowest concentration that has no appreciable impact (<1%) on survival, creates no detectable avoidance (stress) reaction in alevin, is found to support healthy incubation in both field and laboratory research, and has only a minor (8%) expected impact on potential size at hatching. Adjusting the daily average oxygen concentration to obtain an estimate of a protective daily minimum concentration (by subtracting 0.5-1.0 mg/l) results in an estimate that an average daily minimum oxygen concentration should remain at or above 8-8.5 mg/l in the redds for full protection of salmonid incubation. The selection of a specific criteria value is made somewhat problematic, however, by the fact that intragravel oxygen concentrations are less than that of the overlying water column. Depressions commonly cited in the literature typically range from about 1-3 mg/l. Using this range, the research conclusions can be adjusted to a water column concentration. This approach results in the recommendation that to fully protect developing salmonids the average of the daily minimum oxygen concentrations in the water column should remain at or above 9.0-11.5 mg/l. **The proposed criteria should fully protect incubation; except where the rate of oxygen depression from the water column to the gravel is greater than 1.5 mg/l.** Growth rates in juvenile salmonids are influenced by temperature, food availability, and dissolved oxygen. When food availability is high, particularly at warmer temperatures, any depression in oxygen from air saturation rates can be expected to reduce the potential growth rates of fish. When food availability is low, particularly at cool temperatures, fish growth may become independent of dissolved oxygen at concentrations of oxygen well below saturation levels. Since fish rely on the summer growth period to sustain them through the winter, taking full advantage of periods of food availability may be biologically important. However, a wide variety of control stream and laboratory studies were examined. In consideration of all the factors and the strength of the supporting literature, a monthly (or weekly) average concentration of 9.0 mg/l would be the lowest that would

confidently have a negligible effect (1-5%) on growth rates. An average concentration of 8.0 mg/l may allow for greater impacts (3-10%). Although, it is worth noting that some authors were not able to detect a statistically significant difference in the growth effects at 8 and 9 mg/l.

A 9.0 mg/l mean concentration representing the research results can be adjusted to approximate associated daily minimum concentrations (by subtracting 0.5-1.0 mg/l – the typical fluctuation observed in association with mean laboratory test concentrations). This results in the recommendation that to support healthy growth rates in salmonids, monthly (or weekly) average daily minimum oxygen concentrations should be at or above 8-8.5 mg/l. It is important to note that the data also supports the assertion that minor and infrequent (once per week) depressions of oxygen into the range of 5-6 mg/l are highly unlikely to cause measurable reductions in overall growth. So using an average minimum value rather than a single daily minimum to express this growth criteria is a reasonable and safe approach.

The proposed criteria should fully support juvenile growth. At most the proposed criteria would allow for a 5% reduction in growth during worse-case oxygen years.

Depressed oxygen levels affect the distribution and migratory patterns of fish and other aquatic species. Numerous authors have demonstrated that fish will actively avoid dissolved oxygen concentrations above the levels that would cause acute lethality, and that chronically low oxygen levels will determine the presence and distribution of fish species in natural waters. In general, avoidance reactions in salmonids have been noted in both field and laboratory studies to occur consistently at concentrations of 5.0 mg/l and lower. There is some indication, however, that avoidance reactions may sometimes be triggered at concentrations as high as 6.0 mg/l in salmon. Oxygen levels below 5.0-6.0 mg/l should be considered a potential barrier to the movement and habitat selection of salmonids. It is not clear from the research whether or not the fish will avoid waters with average oxygen concentrations below 5-6 mg/l, or would respond even if only the daily minimums fell below this range. It seems warranted to assume that anytime the oxygen concentrations fall below 5-6 mg/l fish will begin to avoid that portion of the waterbody. Thus, treating the values as single daily minimums may be most appropriate to ensure full protection.

The proposed criteria should prevent impairment to the movements of salmonids.

Oxygen concentrations directly affect the speed and endurance capacities of fish. Swimming performance is dependent upon temperature and dissolved oxygen. At optimal temperatures, dissolved oxygen depressions will have less of an effect on the maximum sustained swimming speed than at temperatures either above or below their optimum temperature. In either case, however, any decrease in oxygen level below saturation values will reduce the maximum swimming speed in fish. Given that swimming speed is related to the ability of fish to avoid predation and the ability to hold position or migrate through river currents, decreases in maximum swimming speed should be minimized. An absolute oxygen concentration above 8-9 mg/l would be the lowest oxygen concentration that should be assumed to fully protect the swimming performance of salmonids. Based on the literature, a drop in oxygen from high saturation concentrations (greater than 10 mg/l) to 7 mg/l would be expected to only result in undetectable to modest (5-10%) changes in maximum swimming speed, but below 7 mg/l the impact to swimming speed may become significant. Based on a projection of the data produced by Davis et al. (1975) using coho and chinook salmon the following effect levels would be expected:

- At 9.0 mg/l maximum sustained swimming speed would be reduced less than 2%.
- At 8 mg/l minor decreases in swimming speed (from 3-7%), should be expected.
- At 7 mg/l swimming performance would likely be reduced by 5-10%.

It is important to recognize that reducing the fitness in fish that have long or difficult migrations, and reducing a fish's ability to repeatedly escape predation may produce lethal consequences to the fish. It is also important to acknowledge, however, that no clear empirical evidence exists that suggests a moderate (5-10%) reduction in the maximum sustained swimming speeds will translate into reduced fitness in the field.

Taken together the data reviewed suggests that the swimming fitness of salmonids is maximized when oxygen levels are maintained above 8.0-9.0 mg/l (most appropriately expressed as a daily minimum since the effect is essentially instantaneous). If a longer term average exposure metric (7-30 days or more) is used to express such a criteria, it may be prudent to also include a single daily minimum value that is also in the range of what would provide good support (7 mg/l).

The proposed criteria would allow minor (5-10%) and short-term periods of swimming impairment.

Stream insects include species that are more sensitive to oxygen

	concentrations than fish species. To be confident that all stream macroinvertebrates will be fully protected, headwater streams would need to be protected with a 1-day minimum of 8.5-9.0 mg/l, and mid-elevation waters (e.g., salmonid spawning streams) with 1-day minimums of 7.5-8.0 mg/l . Insects associated with non salmonid waters, or waters used only for salmonid rearing – which would be comprised of lower elevation mainstem waters – would need to be protected with a 1-day minimum of 5.5-6.0 mg/l. Since mountainous headwater streams characteristically do not have problems with human-caused oxygen depletion, focusing only on the requirements of mid-elevation streams may also be reasonably (yet unquantifiably) protective. To have a reasonable probability of being protective, however, such an alternative should be set at a 1-day minimum of 7.5-8.0 mg/l. **The proposed criteria if just barely met in headwater areas would allow for some period where losses to emerging insect populations would occur, but otherwise would remain fully protective.** The effect of oxygen on the metabolism of fish and other aquatic life indirectly affects the capability of these organisms to withstand other environmental stressors. It is clear that maintaining high (>8.5 mg/l) oxygen levels provides added protection from the effects of several very common pollutants, and that low oxygen in combination with wastewater can significantly increase detrimental effects. **The proposed criteria would allow for some periods of time where complementary protection is not ideal, but should remain fully protective overall.** Mortality of juvenile salmonids should be prevented by maintaining single daily minimum oxygen concentrations above 3.9 mg/l and by maintaining weekly or monthly average minimum concentrations above 4.6 mg/l. This protection should be expected even at water temperatures approaching the thermal limits of the fish. Thus both the existing and proposed criteria should fully protect fish against acutely lethal effects. **The proposed criteria will fully guard against direct lethality to adult or juvenile fishes.**
Class A to salmonid spawning and rearing use type	The criteria would change from a single daily minimum of 8.0 mg/l to a 90-day average of the daily minimums of 9.5 with no single day less than 7.0 mg/l. On average the proposed criteria represents a 0.5 mg/l increase in protection for dissolved oxygen. **The same biological analysis as provided above for the change from**

	Class AA to the salmonid spawning and rearing use type would apply to this category; however, in this case the changes would all increase protection from what occurs with the existing Class A criteria (as summarized below): **The proposed criteria would fully protect incubation.** **Both the proposed criteria should fully support juvenile growth.** **The proposed criteria should prevent impairment to the movements of salmonids.** **The proposed criteria would allow minor (5-10%) and short-term periods of swimming impairment.** **The proposed criteria if just barely met in headwater areas would allow for some period where losses to emerging insect populations would occur, but otherwise would remain fully protective.** **The proposed criteria would allow for some periods of time where complementary protection against synergistic effects caused by multiple environmental stressors is not ideal, but should remain fully protective overall.** **The proposed criteria will fully guard against direct lethality to adult or juvenile fishes.**
Class B to salmon and trout rearing-only use type	The criteria would change from a single daily minimum of 6.5 mg/l to a 90-day average of the daily minimums of 8.5 with no single day less than 6.0 mg/l. On average the proposed criteria represents a 1.0 mg/l increase in protection for dissolved oxygen. Growth rates in juvenile salmonids are influenced by temperature, food availability, and dissolved oxygen. When food availability is high, particularly at warmer temperatures, any depression in oxygen from air saturation rates can be expected to reduce the potential growth rates of fish. When food availability is low, particularly at cool temperatures, fish growth may become independent of dissolved oxygen at concentrations of oxygen well below saturation levels. Since fish rely on the summer growth period to sustain them through the winter, taking full advantage of periods of food availability may be biologically important. However, a wide variety of control stream and laboratory studies were examined. In consideration of all the factors and the strength of the supporting literature, a monthly (or weekly) average concentration of 9.0 mg/l would be the lowest that would confidently have a negligible effect (1-5%) on growth rates. An average concentration of 8.0 mg/l may allow for greater impacts (3-10%). Although,

	it is worth noting that some authors were not able to detect a statistically significant difference in the growth effects at 8 and 9 mg/l. A 9.0 mg/l concentration representing the mean concentration reported for the research results can be adjusted to approximate associated daily minimum concentrations (by subtracting 0.5-1.0 mg/l). This results in the recommendation that support healthy growth rates in salmonids, monthly average daily minimum oxygen concentrations should be at or above 8-8.5 mg/l. It is important to note that the data also supports the assertion that minor and infrequent (once per week) depressions of oxygen into the range of 5-6 mg/l are highly unlikely to cause measurable reductions in overall growth. So using an average minimum value rather than a single daily minimum to express this growth criteria is a reasonable and safe approach. An average concentration of 6-7 mg/l as would probably often occur with the existing criteria, however, would likely result in growth rate depressions between 10-20%. **Thus the existing criteria should not be viewed as fully support juvenile growth; however, the more stringent proposed criteria would move growth rates into the range where no or insignificant depression in potential growth rates would be expected.** Depressed oxygen levels affect the distribution and migratory patterns of fish and other aquatic species. Numerous authors have demonstrated that fish will actively avoid dissolved oxygen concentrations above the levels that would cause acute lethality, and that chronically low oxygen levels will determine the presence and distribution of fish species in natural waters. In general, avoidance reactions in salmonids have been noted in both field and laboratory studies to occur consistently at concentrations of 5.0 mg/l and lower. There is some indication, however, that avoidance reactions may sometimes be triggered at concentrations as high as 6.0 mg/l in salmon. Oxygen levels below 5.0-6.0 mg/l should be considered a potential barrier to the movement and habitat selection of salmonids. It is not clear from the research whether or not the fish will avoid waters with average oxygen concentrations below 5-6 mg/l, or would respond even if only the daily minimums fell below this range. It seems warranted to assume that anytime the oxygen concentrations fall below 5-6 mg/l fish will begin to avoid that portion of the waterbody. Thus, treating the values as single daily minimums may be most appropriate to ensure full protection. **The existing criteria should prevent impairment to the movements of salmonids.**

	Oxygen concentrations directly affect the speed and endurance capacities of fish. Swimming performance is dependent upon temperature and dissolved oxygen. At optimal temperatures, dissolved oxygen depressions will have less of an effect on the maximum sustained swimming speed than at temperatures either above or below their optimum temperature. In either case, however, any decrease in oxygen level below saturation values will reduce the maximum swimming speed in fish. Given that swimming speed is related to the ability of fish to avoid predation and the ability to hold position or migrate through river currents, decreases in maximum swimming speed should be minimized. An absolute oxygen concentration above 8-9 mg/l would be the lowest oxygen concentration that should be assumed to fully protect the swimming performance of salmonids. Based on the literature, a drop in oxygen from high saturation concentrations (greater than 10 mg/l) to 7 mg/l would be expected to only result in undetectable to modest (5-10%) changes in maximum swimming speed, but below 7 mg/l the impact to swimming speed may become significant. Based on a projection of the data produced by Davis et al. (1975) using coho and chinook salmon the following effect levels would be expected. • At 9.0 mg/l maximum sustained swimming speed would be reduced less than 2%. • At 8 mg/l minor decreases in swimming speed (from 3-7%), should be expected. • At 7 mg/l swimming performance would likely be reduced by 5-10%. It is important to recognize that reducing the fitness in fish that have long or difficult migrations, and reducing a fish's ability to repeatedly escape predation may produce lethal consequences to the fish. It is also important to acknowledge, however, that no clear empirical evidence exists that suggests a moderate (5-10%) reduction in the maximum sustained swimming speeds will translate into reduced fitness in the field. Taken together the data reviewed suggests that the swimming fitness of salmonids is maximized when oxygen levels are maintained above 8.0-9.0 mg/l (most appropriately expressed as a daily minimum since the effect is essentially instantaneous). If a longer term average exposure metric (7-30 days or more) is used to express such a criteria, it may be prudent to also include a single daily minimum value that is also in the range of what would provide good support (7 mg/l). A 90-day average of the daily minimums of 8.5 mg/l would be similar to a single daily minimum of 7.5 mg/l. This compares to the existing single daily minimum of 6.5 mg/l.

The proposed criteria for Class B waters prevents impairment to swimming performance; however the proposed criteria should keep the reduction in potential performance below 7.5%.

Stream insects include species that are more sensitive to oxygen concentrations than fish species. To be confident that all stream macroinvertebrates will be fully protected, headwater streams would need to be protected with a 1-day minimum of 8.5-9.0 mg/l, and mid-elevation waters (e.g., salmonid spawning streams) with 1-day minimums of 7.5-8.0 mg/l. Insects associated with non salmonid waters, or waters used only for salmonid rearing – which would be comprised of lower elevation mainstem waters – would need to be protected with a 1-day minimum of 5.5-6.0 mg/l. Since mountainous headwater streams characteristically do not have problems with human-caused oxygen depletion, focusing only on the requirements of mid-elevation streams may also be reasonably (yet unquantifiable) protective. To have a reasonable probability of being protective, however, such an alternative should be set at a 1-day minimum of 7.5-8.0 mg/l.

The proposed criteria for Class B waters are expected to fully protect the type of macroinvertebrates expected to occur in these types of waters. The proposed criteria would, however, provide less risk that a Class B waterbody would impair the species that normally occur in the middle reaches of the state's rivers.

The effect of oxygen on the metabolism of fish and other aquatic life indirectly affects the capability of these organisms to withstand other environmental stressors. It is clear that maintaining high (>8.5 mg/l) oxygen levels provides added protection from the effects of several very common pollutants, and that low oxygen in combination with wastewater can significantly increase detrimental effects.

The proposed criteria will provide greater buffering from the additive and synergistic effects of multiple stressors and pollutants.

Mortality of juvenile salmonids should be prevented by maintaining single daily minimum oxygen concentrations above 3.9 mg/l and by maintaining weekly or monthly average minimum concentrations above 4.6 mg/l. This protection should be expected even at water temperatures approaching the thermal limits of the fish. Thus both the existing and proposed criteria should fully protect fish against acutely lethal effects.

The proposed criteria will fully guard against direct lethality to adult or juvenile fishes.

Willingness to Pay

People place a value on fish populations in Washington based on their individual perspective. Sport and commercial fishermen have a direct use value for the fish. The commercial fishermen catch fish for sale and the fish contribute directly to income. Fishermen catch fish for recreation and for food. Buyers have a value based on the food value of fish and the availability of substitutes. Many people also have a value associated with knowing that the fish populations will exist at a greater level than current levels or than current long term trends would indicate.

Willingness to pay also depends on what is happening to the fish population. Willingness to pay is very high for the first fish saved. These fish are the breeding stock that maintain or restore an entire population. Willingness to pay once there are sufficient fish to provide support for the rest of the ecosystem including man have a lower value. Thus the total value of the fish populations increases at a decreasing rate as the fish population itself increases. At the highest populations, where a sizeable share of the fish populations are used as human food, the value of each additional fish caught is simply its value added at dockside.

Estimating Willingness to Pay for Fish Populations

A willingness to pay survey of Washington households conducted in 1998[39] asked if people would be willing to pay approximately $204 million over a 20 year period for an additional 1% increase in fish population of Columbia Migratory Fish.[40]

The survey is based on a hypothetical 20 year program that people pay for on a monthly basis and which creates an increase in the fish population which is measured by the increase in the 20th year. The survey generated two sets of values for the fish population increase: a baseline flat fish population status quo and a baseline declining fish population status quo. People were willing to pay more for improvements in fish populations when the survey was based on the assumption that the fish populations were declining. People were not willing to pay as much when the survey was based on the assumption that the fish populations were stable at 1998 levels. The $204 million value is from the lower of two sets of dollar values. These values are based on the assumption that the fish populations are stable at 1998 levels. The stable population values because they are lower and therefore more conservative.[41] Further, based on other local programs to save the fish, the lower dollar values, which assume increases from a baseline 1998 fish population, are appropriate.

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[39] Valuing Programs to Improve Multi-Species Fisheries, David Layton, Gardner Brown, Mark Plummer, University of Washington, April 1999.
[40] This present value estimate is based on the interest rate for inflation free bonds or 3.63% that was available in Nov. 30 1999, Business Section of the PI, Inflation adjusting Treasury Current Market Rate Coupon rates. We have not adjusted the interest rate to the current one because this was the value available to people when they were answering the survey. This means this value is more heavily discounted than the cost estimates in this same section.
[41] Conservative in this setting means that the value selected is biased against the rule.

The values are limited by the fact that the Department of Natural Resources Forest Practices Rule has already moved forward toward implementation.[42] This analysis takes the additional population increase beyond the first 5%.

> The formula is: Value = [(percent of fish beta*(0-LN(final percent change)/Pbeta)) - (percent of fish beta*(0-LN(5 percent)/Pbeta))].[43]

The recent the Department of Natural Resources Forest Practices Rules were forecasted to have an impact on the regulatory environment and thus the fish. The estimated impact was approximately a 5% impact on the fish populations. The value from this 5% has already been used and can't be used twice.[44] Thus value increases created by new Water Quality Rule Amendment must arise from increases in the fish populations beyond that estimated for the prior rule.

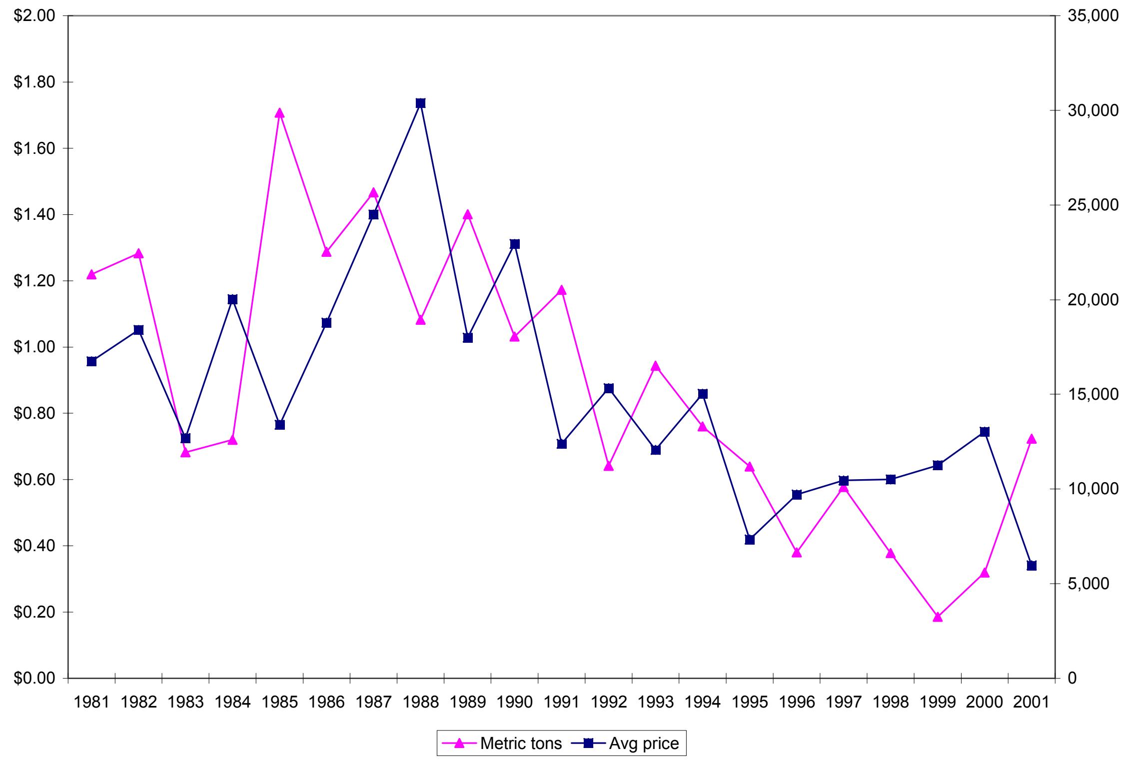
Value in commercial harvest

An increase in the number of fish would not only result in an increased population 20 years from now but also in an increased harvest in the intervening years. These fish are generally valued based on the ex-vessel price.

From the mid 1980's to the turn of the century, salmon harvests in Washington dropped by a factor of about 3½ (based on 3-year running averages of 26,028 tons/year in 1985-1987 down to 7,168 tons/year in 1999-2001). Revenues drop even more strongly, by a factor of almost 9, from $69,100,000/year in 1987-1989 down to $7,766,000/year in 1999-2001. A closer inspection reveals an important fact about prices for Washington salmon. On a year-to-year basis, there is a general tendency for an increase in harvest to be associated with a decrease in price, and vice-versa. This is what basic principles of supply and demand would suggest. A longer horizon, however, gives a different picture, as both harvests and prices have fallen (see Graph 3).

[42] The prior analyses used the initial 5% of the estimated value.
[43] The Beta and Pbeta are based on the nonlinear results in the Layton, Brown, Plummer (99) paper in footnote 2.
[44] The survey asked people to value increases in the fish populations that would occur in 20 years. If a rule saves a fish for the final 20th year population then that fish can't be counted twice. Only additional increases in habitat, creating additional fish population can be called an increase.

Graph 3



This reflects the fact that increased imports from Alaska and Chile, as well as a greater quantity of farmed salmon, have more than made up for the decrease in local harvests. The result has been that Washington harvests are an ever-smaller portion of the supply in the state. This in turn means that local harvests have an every-smaller influence on local prices.

This complicates the calculation of what is to be gained by the increased harvests that might accompany increased stock abundance. It is possible that prices will fall even further. On the other hand some people are eating less salmon because of concerns for the fish and the wild supply, if it grew sufficiently, might out compete imports and farming. But a more neutral projection would be to carry current average prices forward. Given the role of supplies from outside the state, it would be unrealistic to project a significant increase in prices.

The next question is the increased volume of harvest that a recovery would allow. There can be no direct translation from increased abundance to increased harvest. If harvests are an extremely low fraction of total returns of adult fish, they can be increased by a greater percentage than the increase in abundance itself. On the other hand, the commingling of wild and hatchery fish leads to the imposition of lower harvests so as to protect the wild runs, and may prevent the realization of much gain in harvest.

Value in Sportfishing

Table 12

Value of a Fishing Day indexed to 2003				
Type of Fishery	Source	Value per fishing day	Location	Estimation Method
Coldwater	Brown and Plummer (1979)	$ 66.77	WA	HTC
		$ 119.48	OR	HTC
	Vaughan and Russell (1982)	$ 40.41	US	TC
		$ 52.67		
		$ 55.71	US	CV
	Miller and Hay (1984)	$ 55.71	ID	TC
	Sorg *et al.* (1985)	$ 27.64	ID	CV
		$ 45.17	ID	TC
	Brown and Hay(1987)	$ 24.75	US	CV
	Wade *et al*. (1988)	$ 28.90	CA	TC
Salmon	Matthews and Brown (1970)	$ 175.13	WA	CV
	Crutchfield and Schelle (1978)	$ 45.85	WA	CV
	Brown, Sorhus, and Gibbs (1980)	$ 61.27	WA	TC
		$ 101.70	OR	TC
Trout	USFWS (1980)	$ 26.03	ID	CV
		$ 29.19	US	CV
	Vaughan and Russell (1982)	$ 42.75	US	TC
	Waddington, Boyle, and Cooper (1994)	$ 37.99	WA	TC
Saltwater	Rowe et al. (1985)	$ 90.80	Pacific Coast	TC
Warmwater	Vaughan and Russell (1982)	$ 25.84	US	TC
		$ 35.38		
		$ 39.80	US	CV
	Sorg *et al.* (1985)	$ 21.12	ID	CV
		$ 46.60	ID	TC
	Hay (1988)	$ 20.34	NW	CV

Table drawn from Gardner Brown and Mark Plummer, Fisheries Benefits of Five Department of Ecology Rules, 1997.
All citations are in that document.
TC means Travel Cost
HTC means Hedonic Travel Cost
CV means Contingent Valuation

The value of sport caught fish is based on the value of a fishing day for one individual. The value of salmon fishing of $61.27 would be an appropriate estimate of value for any increases in salmon fishing days generated by this rule amendment.

Land values for residential and recreational uses

The value of land can be limited by poor water quality.[45] If the water quality is perceived by buyers either because it is visible or because a shoreline has a health warning, then willingness to pay for the property will be affected. Further, the willingness to invest in the property through maintenance and the addition of improvements may be affected (Epp & Al-Ani). In so far as this occurs, there can be a neighborhood effect that masks the value shift initially created by the water quality change.

The following studies tend to indicate that improvements in water quality may have an impact on the price of residential or recreation land that is located on the water. The value shift in the more relevant articles in the literature ranges from 1% to 20%. The Leggett and Bockstael (2000) study is the best of these in that it included a wide variety of potentially confounding variables in the specification. It places a 100 m/L change in Fecal Coliform at a 1.5% change in the value of the property.

Table 13

Source	Date	Impact	Type of property	Property Value Shift
Leggett & Bockstael	2000	Fecal Coliform (100 mL)	Residential, Chesapeake Bay	1.50%
Ribaudo, Young, & Epp, USDA	1984	Algae, phosphorous	Vermont, Recreational Homes	20%
David	1968	Subjective	Wisconsin, Lake property net of improvements	0.83%
Steinnes	1991	Water Clarity: Added Value per Added Foot of Depth	Minnesota, Lake property Calculated for 1 acre lot with 121 front feet	2.30%
Epp & Al-Ani	1979	pH	Pennsylvania, Rural residential property	5.90%
		pH	Less building in areas with poor water quality: ratio of older homes in polluted/clean areas	1.42
Michael, Boyle, Bouchard	1996	Water Clarity: Added Value per Added Foot of Depth	Maine, Lakes	15%

[45] Elizabeth L. David, Lakeshore Property Values: A guide to public investment in Recreation, *Water Resources Research*, vol.4, no. 4, August 1968.
Donald J. Epp and K. S. Al-Ani, The Effect of Water Quality on Rural Nonfarm Residential Property, *American Journal of Agricultural Economics*, vol. 61, No. 3, 1979, pgs. 529-34.
Christopher G. Leggett and Nancy E Bockstael, Evidence of the Effects of Water Quality on Residential Land Prices, *Journal of Environmental Economics and Management*, Vol. 39, 2000, pgs. 121-144.
Jules M. Pretty, Christopher F. Mason, David B. Nedwell, Rachel E. Hine, Simon Leaf, and Rachel Dils, Environmental Costs of Freshwater Eutrophication in England and Wales, Environmental Science and Technology, Vol. 37, No. 2 2003, pgs 201-208.
Mark Ribaudo, C. Edwin Young, Donald Epp, *Recreation Benefits from an Improvement in Water Quality on St. Albans Bay, Vermont*, USDA, Economic Research Service, Natural Resource Economics Division, January 1984, AGES 831116.
Donald Steinnes, Measuring the Economic Value of Water Quality: the case of lakeshore land, *The Annals of Regional Science*, Spring, 1992 (26), pgs 171-176.
C. Edwin Young, Perceived Water Quality and the Value of Seasonal Homes, *Water Resources Bulletin*, April 1984, pg. 163 – 168.

Table 14

	Lake and river length of shore		Shoreline affected in lf.	
County	Unincorporated	Incorporated	Unincorporated	Incorporated
Adams	1,177.5	0.0	26.1	-
Asotin	2.5	700.2	0.1	15.5
Benton	2,283.1	2302.1	50.6	51.0
Chelan	46,973.8	24995.0	1,041.4	554.1
Clallam	70,076.7	0.0	1,553.5	-
Clark	234,682.8	92397.9	5,202.7	2,048.4
Columbia	40.4	2853.8	0.9	63.3
Cowlitz	78,591.8	11626.7	1,742.3	257.8
Douglas	13,745.1	5975.4	304.7	132.5
Ferry	3,029.9	0.0	67.2	-
Franklin	-	0.0	-	-
Garfield	-	0.0	-	-
Grant	10,394.9	19379.2	230.4	429.6
Grays Harbor	80,585.2	26605.8	1,786.5	589.8
Island	13,259.5	0.0	294.0	-
Jefferson	51,673.4	1310.9	1,145.6	29.1
King	431,528.7	601814.2	9,566.6	13,341.7
Kitsap	64,918.8	17150.0	1,439.2	380.2
Kittitas	15,133.3	3069.4	335.5	68.0
Klickitat	33,110.9	9984.3	734.0	221.3
Lewis	94,896.7	22757.3	2,103.8	504.5
Lincoln	2,389.7	12851.1	53.0	284.9
Mason	269,933.3	8269.2	5,984.2	183.3
Okanogan	78,953.5	35141.4	1,750.3	779.1
Pacific	65,820.5	3731.7	1,459.2	82.7
Pend Oreille	59,088.7	3600.2	1,309.9	79.8
Pierce	238,234.2	179412.7	5,281.4	3,977.4
San Juan	762.4	0.0	16.9	-
Skagit	135,387.7	6789.1	3,001.4	150.5
Skamania	94,909.8	14460.9	2,104.1	320.6
Snohomish	412,521.3	72436.8	9,145.2	1,605.9
Spokane	166,432.1	59916.4	3,689.6	1,328.3
Stevens	99,674.7	9805.7	2,209.7	217.4
Thurston	181,600.1	35640.5	4,025.9	790.1
Wahkiakum	23,391.2	4001.4	518.6	88.7
Walla Walla	1,365.7	24159.1	30.3	535.6
Whatcom	174,937.0	54544.8	3,878.2	1,209.2
Whitman	10,516.7	52429.1	233.1	1,162.3
Yakima	31,425.2	1338.1	696.7	29.7

Given that the permit changes may affect from 2% of the waterbodies, some economic value may accrue from this. However, the effect will be limited by whether or not people perceive the change in water quality. The water quality measure of TSS (Total Suspended Solids) is easily visible and is linked to nutrient loading and algal blooms. Changes in Fecal Coliform will be "visible" only if they are measured and beaches are posted or if people become noticeably ill.

The Raw Data

The next question is how much shoreline in Washington may be affected? The studies all refer to residential property. Thus only the residential shoreline is potentially affected. Unicorp data[46] indicates how many feet of residential shoreline are in each county. This is adjusted based on the share of waterbodies which might on a statewide average be affected by permit changes, 2%.

[46] Aggregation of the data was done for this rule by Shidong Zhang, Economist at Ecology.

The data used to estimate the value of the shoreline property came from a variety of sources.

- King and Thurston County data (the green data, which should print in gray) are from the assessor's database.
- For many other counties data (the yellow data, which should print in pale gray with no grid) were sampled at www.realtor.com. Time 2/19/2003.

For the remaining data, since it extrapolates from high density areas to low density areas it certainly overestimates the prices.

- Ruraldata - Only two counties had data available, King County and Thurston County. So other cities use Thurston County data to make estimates on rural property.
- City data - Only big cities have enough samples, so each county is represented by data from its biggest city.
- The remaining city data are estimated based on the best knowledge available:
  Eastern Washington: Spokane data.
  Pacific coast: Port Angeles data.
  Puget Sound: assign a "reasonable" value between areas of knowledge.

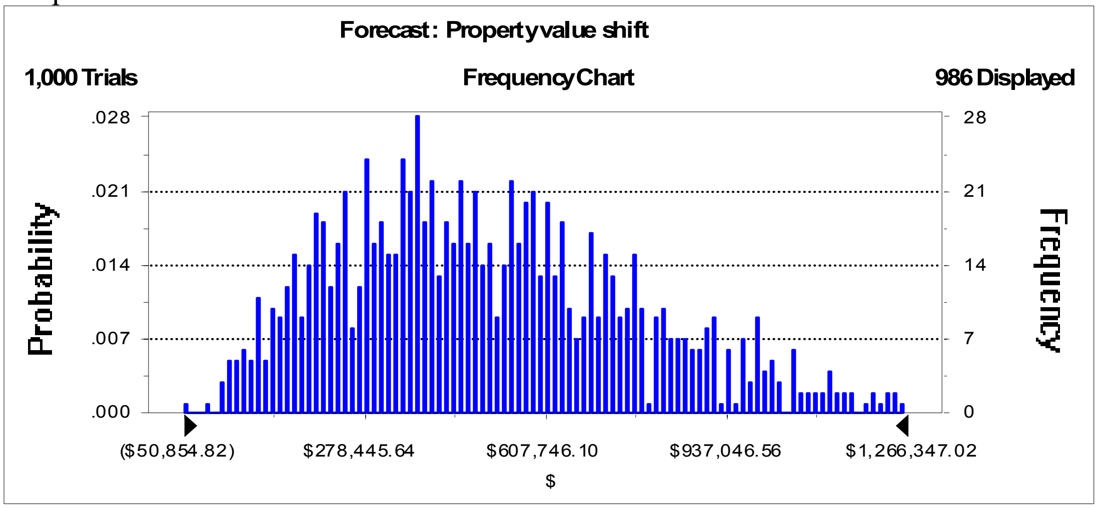
Given that the value of shoreline is generally an over estimate this value was adjusted based on the lowest estimate of the water quality impact in the studies, .83%.

Table 15

Shifts in the value of residential land				
County	Average price/SQFT (cities)	Average price/SQFT (Other)	Estimated Price per Lineal Foot of Lot SL (city)	Estimated Price per Lineal Foot of Lot SL (Other)
Adams	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Asotin	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Benton	$ 1.64	$ 0.27	$ 245.87	$ 55.00
Chelan	$ 1.37	$ 0.27	$ 205.86	$ 55.00
Clallam	$ 0.47	$ 0.27	$ 70.81	$ 55.00
Clark	$ 3.87	$ 0.27	$ 581.08	$ 55.00
Columbia	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Cowlitz	$ 1.80	$ 0.27	$ 270.00	$ 55.00
Douglas	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Ferry	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Franklin	$ 1.47	$ 0.27	$ 220.67	$ 55.00
Garfield	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Grant	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Grays Harbor	$ 0.44	$ 0.27	$ 66.51	$ 55.00
Island	$ 4.00	$ 0.27	$ 600.00	$ 55.00
Jefferson	$ 0.47	$ 0.27	$ 70.81	$ 55.00
King		$ 0.36		$ 71.46
Seattle_Mercer Island	$ 21.27		$ 3,190.52	
Bellevue, Redmond, Kirkland	$ 10.14		$ 1,521.18	
OtherCities	$ 4.10		$ 614.56	
Kitsap	$ 3.24	$ 0.27	$ 486.31	$ 55.00
Kittitas	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Klickitat	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Lewis	$ 1.80	$ 0.27	$ 270.00	$ 55.00
Lincoln	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Mason	$ 1.80	$ 0.27	$ 270.00	$ 55.00
Okanogan	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Pacific	$ 0.47	$ 0.27	$ 70.81	$ 55.00
Pend Oreille	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Pierce	$ 3.49	$ 0.27	$ 523.86	$ 55.00
San Juan	$ 4.00	$ 0.27	$ 600.00	$ 55.00
Skagit	$ 2.00	$ 0.27	$ 300.00	$ 55.00
Skamania	$ 1.20	$ 0.27	$ 180.00	$ 55.00
Snohomish	$ 6.86	$ 0.27	$ 1,028.40	$ 55.00
Spokane	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Stevens	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Thurston	$ 2.22	$ 0.27	$ 332.88	$ 55.00
Wahkiakum	$ 1.20	$ 0.27	$ 180.00	$ 55.00
Walla Walla	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Whatcom	$ 1.61	$ 0.27	$ 242.24	$ 55.00
Whitman	$ 0.96	$ 0.27	$ 143.56	$ 55.00
Yakima	$ 0.98	$ 0.27	$ 146.30	$ 55.00

The value of residential shoreline is thus adjusted by the small share of potentially affected shoreline (2.2%) and by the small adjustment in the expected value (0.83%). The share of shoreline affected is defined by the number of permits affected. Where the rule change decreases water quality losses may also occur. Therefore the value of the residential shift changes when the sensitivity test is run. It ranges from -$50,000 to +$1.9 million. The average estimate is $500,000. The negative portion of the range would come from any degradation predicted by the sensitivity test in the current Class AA areas.

Graph 4



Finally, some additional benefits may accrue if the permit holders chose to use restoration as a mechanism for reducing temperature, increasing dissolved oxygen and reducing BOD. California homes near stream restoration projects had 3% to 13% higher property values than similar homes along un-restored streams.[47] However it is not possible to predict whether this option will be chosen by any permitees so no value is assessed.

[47] Schueler, T.R. and H.K. Holland, Editors, The Practice of Watershed Protection, the Center for Watershed Protection, Ellicott City, MD, 2000.

Appendix A

Comparison of proposed Changes to existing standards and federal requirements

Crosswalk between 9/97 Current Standards and 12/02 Proposed Standards (WAC 173-201A)			
Current Standards 9/97	**Proposed Standards 12/02**	**Federal Requirement**	**Analysis**
173-201A-010 Introduction	173-201A-010 Purpose *Modified*	CFR 131.2	
173-201A-020 Definitions	173-201A-020 Definitions *Modified*	Not required.	*Probable that impact occurs elsewhere in the rule – no analysis*
173-201A-030 General water use and criteria classes	173-201A-200 Fresh water designated uses and criteria 173-201A-210 Marine water designated uses and criteria *Modified*	CFR 131.10-Designated uses CFR 131.11-Criteria	
Fecal coliform for fresh & marine waters: 030(1)(c)(i) (A)(B) 030(2)(c)(i)(A)(B) 030(3)(c)(i)(A)(B) 030(4)(c)(i) 030(5)(c)(i)	Bacteria: Fresh water 200(2)(b) Marine water 210(1)(g) and 210(2)(b) *Modified*	WA's proposal is stricter than 2002 EPA Draft Revision of the Federal Guidance on Bacteria	Analysis indicates cost is smaller than the worst case costs. Proposed criteria is consistent with existing federal guidance and national criteria recommendations for the protection of primary contact recreation. Secondary contact protection was made less stringent then the current state standards.
Dissolved Oxygen-Fresh 030(1)(c)(ii)(A) 030(2)(c)(ii)(A) 030(3)(c)(ii)(A) 030(4)(c)(ii) 030(5)(c)(ii)	Dissolved oxygen Fresh water 200(1)(d) *Modified*	Old guidance, updated by the state using more recent research.	Analysis Done: Proposed criteria is consistent with existing federal guidance on the needs of the species and lifestages existing in Washington State; such factors negate the direct use of the national criteria.
Temperature-Fresh 030(1)(c)(iv) 030(2)(c)(iv) 030(3)(c)(iv) 030(4)(c)(iii) 030(5)(c)(iv)	Temperature Fresh water 200(1)(c) *Modified*	1972 Guidance—outdated and updated by the state using more recent research, Region 10 Guidance drafted but not finalized.	Analysis done
Agriculture water supply 030(1)(b)(i) 030(2)(b)(i) 030(3)(b)(i) 030(5)(b)(i)	Agriculture water supply for fresh water 200(3)(b) *Modified to reference narrative criteria and add new numeric criteria*	1972 Guidance for Irrigation water supply: Elec. Conductivity: *no specific recommendation* Bicarbonate-*no specific recommendation* TSS=*No specific recommendation*	Analysis indicates cost is smaller than the worst case costs. 131.10(a) requires states consider the use and value of agricultural water supplies when setting standards. 131.11(a) requires that states adopt criteria to protect designated uses, such as agricultural water supplies,

			based on sound scientific rationale and must contain sufficient parameters or constituents to protect the use.
Toxic narrative: 030(1)(c)(vii) 030(2)(c)(vii) 030(3)(c)(vii) 030(4)(c)(vi) 030(5)(c)(vii)	Narrative standard for toxic, radioactive & deleterious 260(a) *Same as 9/97*	*No change*	
Aesthetic narrative: 030(1)(c)(viii) 030(2)(c)(viii) 030(3)(c)(viii) 030(4)(c)(vii) 030(5)(c)(viii)	Narrative standard for aesthetic values 260(b) *Same as 9/97*	*No change*	
	Narrative standard for nonpoint source pollution 260(c) *New narrative standard*		
173-201A-030(6) Establishing lake nutrient criteria.	173-201A-230 Establishing lake nutrient criteria *Same as 9/97*	*No Change*	
173-201A-040 Toxic substances	173-201A-240 Toxic substances *Modified for Ammonia and minor clarification edits for other toxic criteria*	CFR 131.36-Toxics Criteria for those states not complying with CWA section 303(c)(2)(b).	
040(3)-Table of Toxic criteria	Table 240(3)(f) & (g) Ammonia equations *Modified*	*Partial change based on updated EPA guidance. Does not use the EPA recommended chronic values in salmonid waters due to concerns over conflicts in cited studies. Result is that the current EPA approved state criteria for chronic protection remains in place in salmonid waters.*	EPA cost imposed is exempt.
173-201A-050 Radioactive substances	173-201A-250 Radioactive substances *Same as 9/97*	*No change*	
173-201A-060 General considerations	173-201A-260 Application of water quality criteria *See below*	*No substantive changes in this section—all parts moved to other sections*	
060(1)	260(3)(d)	*No change*	
060(2)	260(e)(i)-(ii)	*No change*	
060(3)	200(2)(b)(i)	*No change*	
060(4)(a)-(b)	200(1)(f)(i)-(iv)	*No substantive change*	
060(5)	510(1)(a)-(b)	*No substantive change*	
060(6)	510(1)	*No substantive change*	

060(7)	260(3)(g)	*No substantive change*	
060(8)	260(3)(h)	*No substantive change*	
060(9)	200(1)(c)(vii)	*No change*	
060(10)(a)-(c)	260(3)(i)(i)-(iii)	*No change*	
070(2)	260(2) Natural and irreversible conditions *Modified*	*Statement on natural conditions broadened to include human structural changes as determined consistent with 40 CFR 131.10(g)(3)&(4)*	*Cost reducing*
	260(3)(f) Human created waters	*New subsection for exempting human-created waters managed primarily for the removal or containment of pollution. Not federal requirement.*	*Cost reducing*
173-201A-070 Antidegradation	173-201A-300 Purpose of antidegradation 173-201A-310 Protection of existing uses 173-201A-320 Protection of waters with better water quality than the standards *Modified*	CFR 131.12- Antidegradation	*Cost reducing features*
173-201A-080 Outstanding resource waters	173-201A-330 Protection of Outstanding National Resource Waters *Modified*	CFR 131.12- Antidegradation Protection only occurs after future rulemakings naming affected waterbodies.	*Cost reducing*
173-201A-100 Mixing zones	173-201A-400 Mixing zones *Same as 9/97*	*No change.*	*Analysis through temperature change for any mixing zone impacts.*
173-201A-110 Short-term modifications	173-201A-410 Short-term modifications *Modified*	*Eliminated requirement to keep modifications only to 1-year unless a long-term management plan is in place.*	*Cost reducing*
	173-201A-420 Variances *New Section*	Must comply with CFR 131.10(g)	
	173-201A-430 Site specific criteria *New Section*	Must comply with CFR 131.10	
	173-201A-440 Use attainability analysis *New Section*	Must comply with CFR 131.10	
	173-201A-450 Water quality offsets *New Section*	*No federal requirement*	*Cost reducing*
173-201A-120 General classifications	*Incorporated into 173-201A-602 and 612*	*No substantive change.*	
173-201A-130	173-201A-600 Table 602	131.10(a) requires states	

Specific classifications -- Freshwater	Most stringent use designations for fresh waters by Water Resource Inventory Area (WRIA) *Modified*	specify appropriate uses that must be achieved and protected. 131.11(a) requires that states adopt criteria to protect designated uses based on sound scientific rationale and must contain sufficient parameters or constituents to protect the use.	
173-201A-140 Specific classifications -- Marine water	173-201A-610 Table 612 Most stringent use designations for marine waters *Modified*	131.10 requires states specify appropriate uses that must be achieved and protected. 131.11(a) requires that states adopt criteria to protect designated uses based on sound scientific rationale and must contain sufficient parameters or constituents to protect the use.	
173-201A-150 Achievement considerations	173-201A-500 Achievement considerations *Same as 9/97*	*No change*	
173-201A-160 Implementation	173-201A-510 Means of implementation *Modified*	*No substantive change*	
	510(5) Compliance schedules for dams *New subsection to address dams*	*New subsection. No federal requirement.*	*Cost reducing: Current standards do not allow compliance schedules for 401 certifications of dams. Remainder of section clarifies need to remain consistent with 131.10 on use protection.*
173-201A-170 Surveillance	173-201A-520 Monitoring and compliance *Same as 9/97*	*No change*	
173-201A-180 Enforcement	173-201A-530 Enforcement *Same as 9/97*	*No change*	

Appendix B

Agriculture

Forest Practices

March 27, 2003

TO: File

FROM: Dave Peeler

SUBJECT: The effect of changes to the state water quality standards on agricultural practices for the purposes of the Cost-Benefit Determination

Minimal effect

One of the purposes of the Clean Water Act is to protect beneficial uses, which include those (among others) aquatic species that depend on clean, cold water for survival.

The proposed changes for temperature criteria will change the water quality standards in a variety of ways. The criteria to protect bull trout will change to 13ºC. The char default generally applies above 700' (West side) and 2000' (East side). The vast majority of char streams are in forested areas, and only a small percentage is in agricultural land – about 0.4% according to analysis.

The criteria for the protection of salmon spawning and rearing in the proposed rule is changed to 16ºC 7-DADMax (approximately equivalent to 17ºC daily maximum).

- This translates to approximately one degree <u>more stringent</u> for water bodies that are regulated under the current Class A 18 ºC daily maximum.
- It is approximately one degree <u>less stringent</u> for water bodies currently regulated under the current Class AA 16 ºC daily maximum.

The Forest Practices shade manual was used to determine the additional percent shade that would be needed to meet the 1ºC degree decrease for class A streams. In eastern Washington, the average elevation of agricultural land is less than 1800 feet. This is based on an analysis of a GIS elevation data layer (analysis attached). In the eastern Washington shade curves for forest practices, any stream at an elevation of less than 2100 feet needs 100 percent shade in order to protect beneficial uses sensitive to temperature under the new standard of (16ºC -7DADMax) 17ºC daily maximum. The current standards would require 100% shade on streams below 1800 feet for class A streams. There would be no significant impact to the agricultural sector as a whole in the amount of shade required for salmonid streams since the average elevation of agricultural activities in eastern Washington is less than 1800 feet.

Elevation requiring 100% Shade	Temperature to be met
2,400 feet	16 ºC daily maximum.
2,100 feet	17ºC daily maximum (approximately equivalent to 16ºC - 7DADMax)
1,800 feet	18ºC daily maximum.

For western Washington, the median elevation for agricultural land is approximately 150 feet. Using the Forest Practices shade curves for western Washington, there is an approximate change of 6 to 8 percent more shade needed on class A streams and 6 to 8 percent less shade needed on class AA streams. Determining what 6-8% shade would mean in terms of more implementation is impractical. That, coupled with the error rate for determining shade, led Ecology to believe that the increased shade that may be needed to keep water cool in agricultural areas in western Washington is also negligible.

Mitigating measures:

- **<u>Conservation Reserve Enhancement Program (CREP)</u>**

  USDA Farm Service Agency (FSA), Commodity Credit Corporation (CCC), and the State of Washington have agreed to implement a voluntary Conservation Reserve Enhancement Program (CREP) to improve the water quality of streams providing habitat for salmon species listed under the Federal Endangered Species Act. The project area includes all streams in Washington crossing agricultural lands providing spawning habitat for the endangered salmon species.

  The Washington State Enhancement Program is authorized to enroll up to 100,000 acres to be devoted to riparian buffers planted to trees. CCC will pay applicable land rental costs, 50 percent of the cost of establishing conservation practices, an annual maintenance incentive, and a portion of the costs of providing technical assistance. The State of Washington will pay 37.5 percent of the cost of establishing conservation practices, all the costs of the annual monitoring program, and a portion of the technical assistance costs.

  Annual rental payments will be based on the soil rental rate, as calculated by FSA. For installing the riparian buffer, producers will receive each year an incentive payment 50 percent above the annual per acre rental rate. Additionally, producers will receive a 10-percent incentive payment for lands protected as agricultural lands under the Washington Growth Management Act.

- **<u>Environmental Quality Incentives Program (EQIP)</u>**

  The Environmental Quality Incentives Program provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation. The purposes of the program are achieved through the implementation of a conservation plan which includes structural, vegetative, and land management practices on eligible land. Five- to ten-year contracts are made with eligible producers. Cost-share payments may be made to implement one or more eligible structural or vegetative practices, such as animal waste management facilities, terraces, filter strips, tree planting, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices, such as nutrient management, pest management, and grazing land management.

The major focus of EQIP in Washington has been to address surface water quality concerns, threatened and endangered species, soil erosion, and water quantity. Significant financial assistance has been used for installing animal waste systems, irrigation conversion to more efficient systems, nutrient management, pest management and conservation tillage systems.

Approximately 1600 bids requesting $40 million dollars have been made.

Washington State has approximately 800 contracts obligating $16.8 million dollars of cost share to implement conservation practices.

- **Regulating the Effect of Farms on Water Quality**

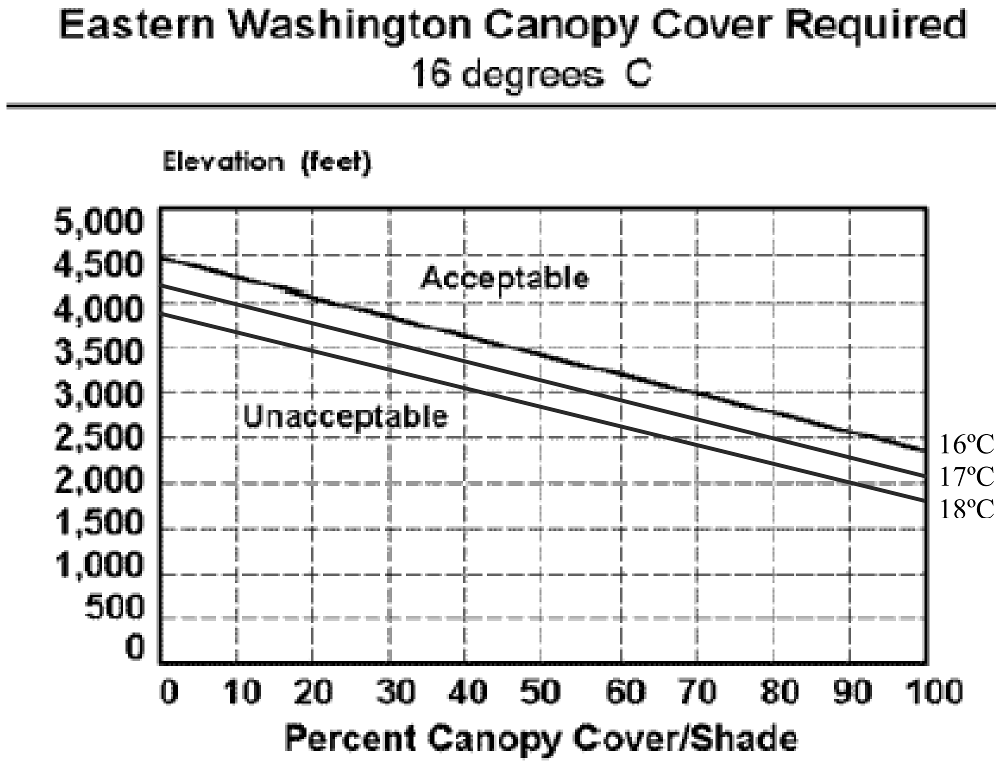
Ecology has significant discretion to tailor nonpoint sources control efforts to avoid over-regulation. In some areas only narrow filter strips of perennial grass may be needed to protect aquatic systems, in others only a narrow stand of healthy trees will accomplish the needed protection, while still in others the nature of the farm runoff combined with the type of affected stream may demand that both a filter strip and a treed buffer be provided.

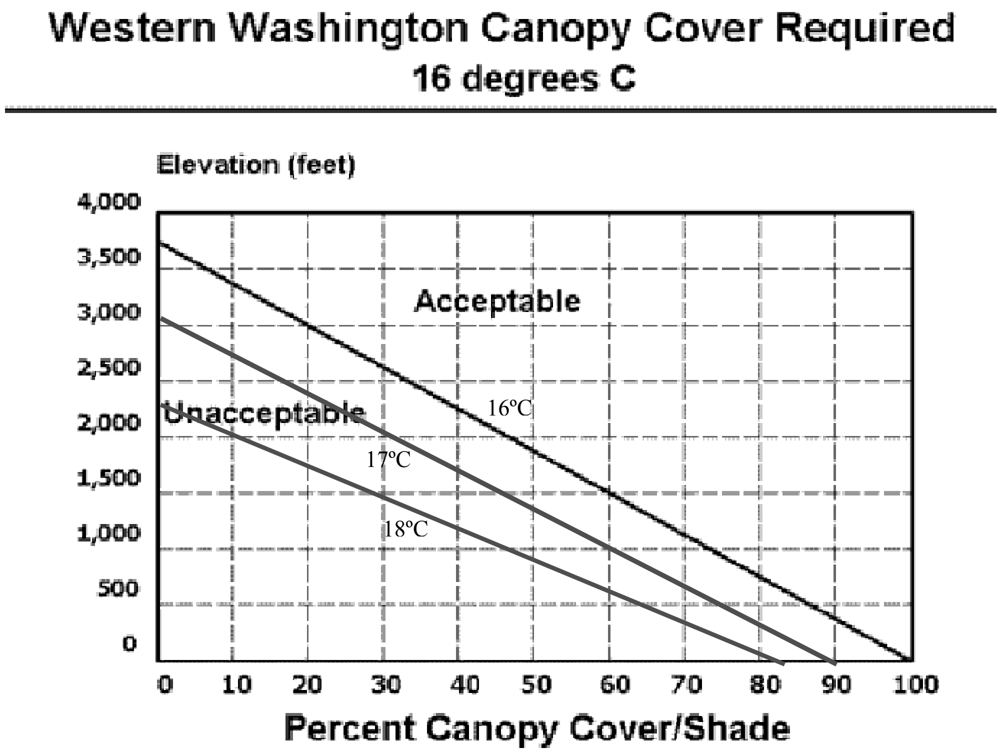
The regulatory requirements for nonpoint sources are often misunderstood. The federal Clean Water Act and the State Water Quality Act both provide high goals and expectations for all sources of pollution, but both also grant the state considerable flexibility in how it manages nonpoint source control programs. The state can use educational programs, cost-assistance programs, or punitive regulatory programs in almost any combination. The state's aim is to slowly develop programs using adaptive management to determine the most cost effective combinations of best management practices and best balance of educational and incentive-based programs. Adaptive management is the practice of deliberately testing out management practices in defined sets or one at a time to evaluate their relative cost-effectiveness. It has the intended purpose of preventing more practices from being recommended or required than we are sure are necessary to protect water quality. The discretion provided under the Act's also allows Ecology to ensure that the circumstances of individual farms are taken into account when recommending or requiring best management practices.

While enforcement actions do sometimes occur, Ecology, views these measures as an unwelcome course of action. Although it is often the measure of focus in the media, agricultural enforcement is reserved for individuals that are causing clear harm to water quality but who are unwilling to respond to reasonable schedules for improving conditions. Ecology, through a cooperative agreement, lets local conservation district staff work one-on-one with farms that are causing significant problems. District staff helps the farmer develop farm plans that are designed for the particular situation. Two years, or more depending upon the situation, is provided for cooperating farms to move into full compliance with the farm plans prior to Ecology coming back into the picture and considering the need for enforcement action. Apart from situations where the department is trying to alleviate significant sources of water quality degradation, the tools that Ecology rely on are those that promote voluntary change: education, technical assistance, and financial support

Conclusion:

No economic analysis of agricultural practices is included in this CBA because Ecology expects that the effect of the standards on change on agricultural lands will be minimal and there are mechanisms in place to mitigate costs to landowners.


Eastern Washington Canopy Cover Required
16 degrees C
Elevation (feet)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Acceptable
Unacceptable
16ºC
17ºC
18ºC
0 10 20 30 40 50 60 70 80 90 100
Percent Canopy Cover/Shade

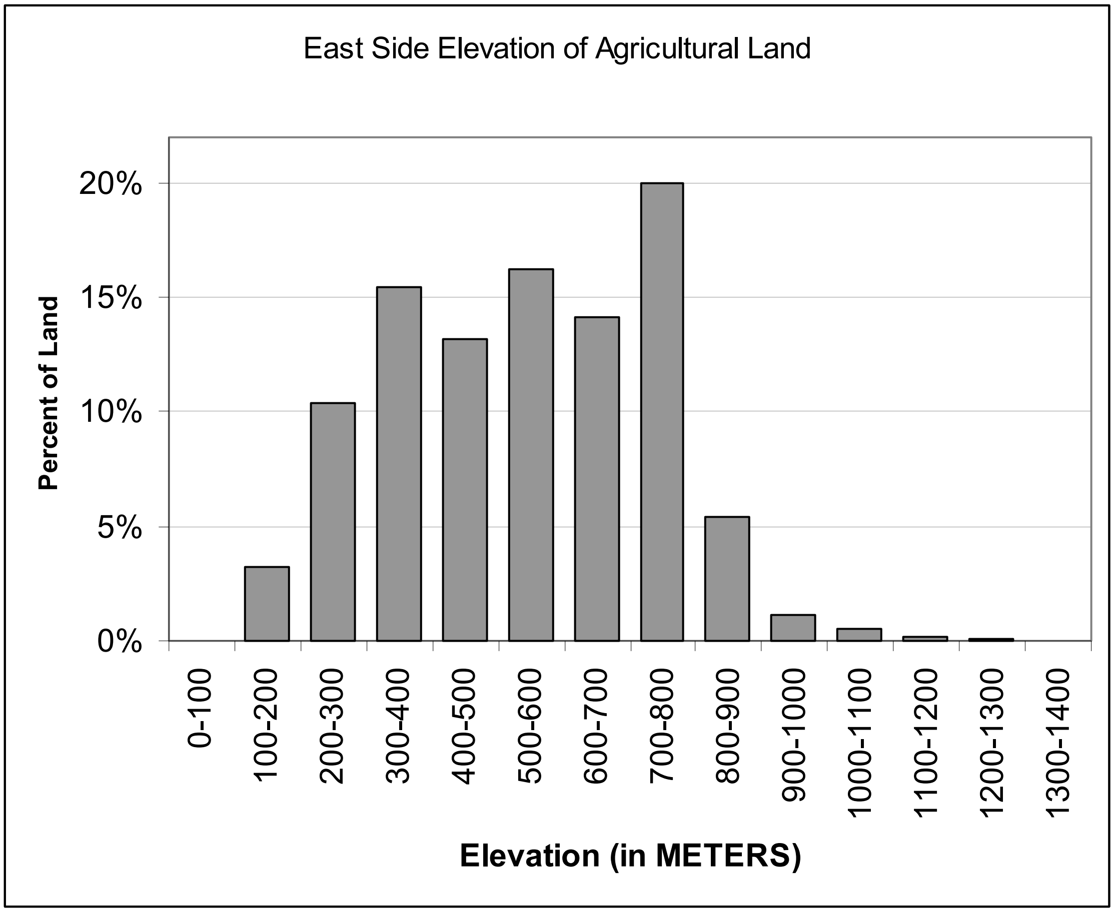

Western Washington Canopy Cover Required
16 degrees C
Elevation (feet)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Acceptable
Unacceptable
16ºC
17ºC
18ºC
0
10
20
30
40
50
60
70
80
90
100
Percent Canopy Cover/Shade

Elevation of Agricultural Land in Washington

NOTE: ***All Elevations are in Meters!*** *(A conversion chart is attached)*
"Count" is the number of cells on the map, which is simply a measure of land area.

Summary of Results – East Side Data

Average East Side Elevation: 541 Meters

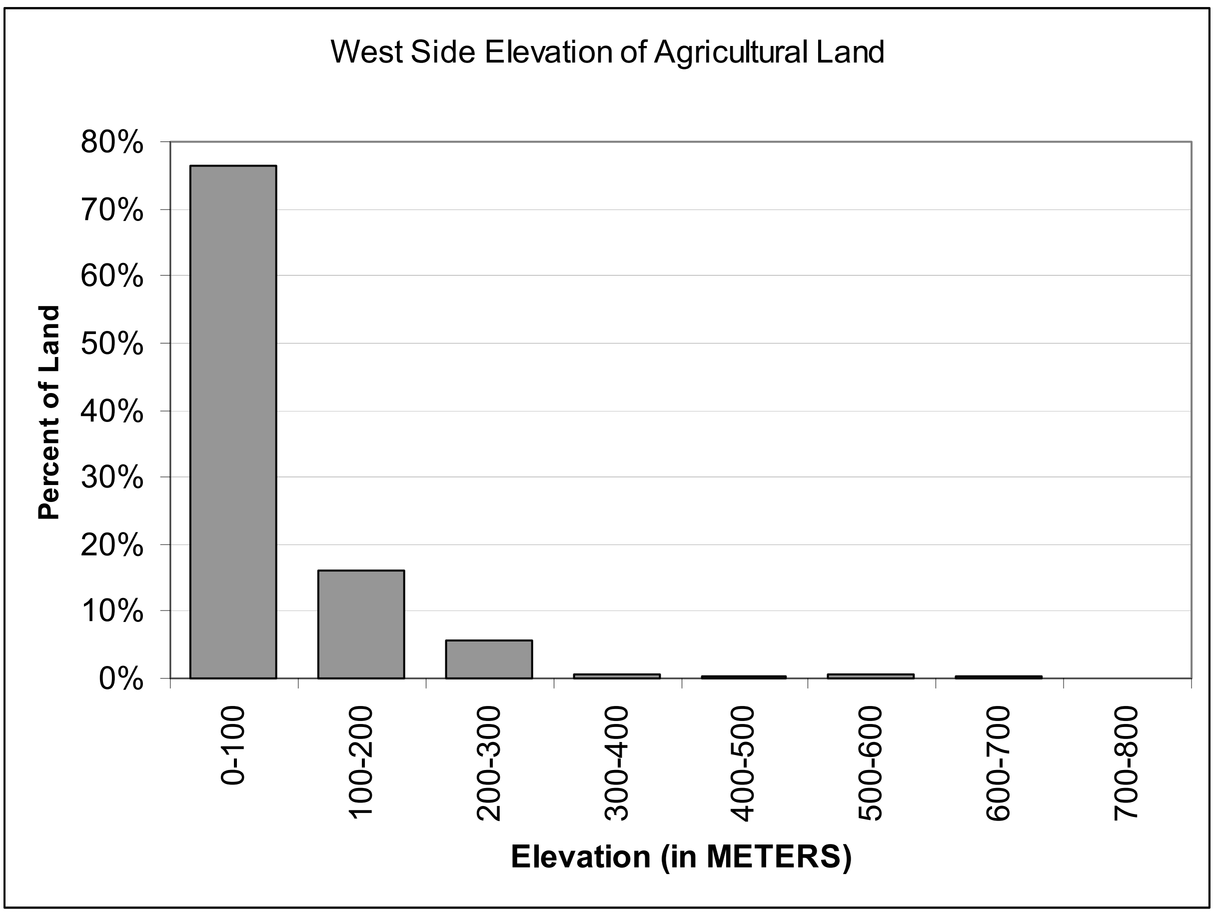


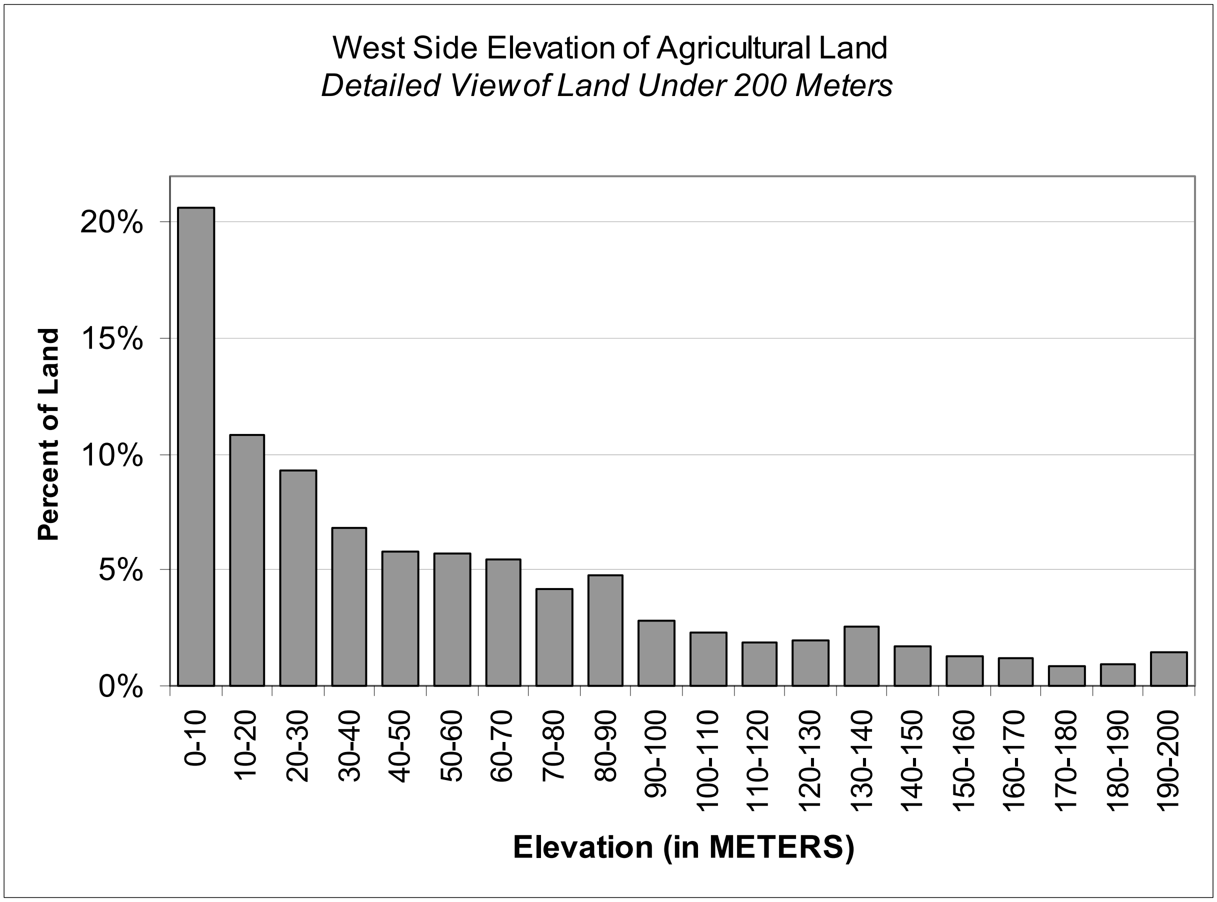
Elev (m) Range	Count	Percent of Count
0-100	10,114	0.03%
100-200	979,308	3.23%
200-300	3,153,089	10.4%
300-400	4,670,767	15.4%
400-500	3,992,168	13.2%
500-600	4,911,716	16.2%
600-700	4,274,477	14.1%

700-800	6,070,211	20.0%
800-900	1,635,098	5.4%
900-1000	343,737	1.1%
1000-1100	164,469	0.5%
1100-1200	61,523	0.2%
1200-1300	25,741	0.1%
1300-1400	7,395	0.024%
1400-1500	1,094	0.0036%
1500-1600	173	0.00057%
1600-1700	69	0.00023%
1700-1800	20	0.00007%
1800-1900	6	0.00002%

Summary of Results – West Side Data

Average West Side Elevation: 73 Meters





Elev (m) Range	Count	Percent of Count
0-100	2,426,074	76%
100-200	512,356	16%
200-300	179,800	5.7%
300-400	19,131	0.60%
400-500	13,726	0.43%
500-600	18,837	0.59%
600-700	5,189	0.16%
700-800	2,413	0.08%
800-900	221	0.0070%
900-1000	141	0.0044%
1000-1100	149	0.0047%
1100-1200	82	0.0026%
1200-1300	46	0.0014%
1300-1400	26	0.0008%
1400-1500	3	0.00009%
1500-1600	2	0.00006%

10-20	344,961	11%
20-30	294,116	9%
30-40	217,626	7%
40-50	184,210	6%
50-60	181,574	6%
60-70	174,685	5%
70-80	131,743	4%
80-90	150,993	5%
90-100	89,763	3%
100-110	74,110	2%
110-120	59,561	2%
120-130	62,717	2%
130-140	81,677	3%
140-150	53,721	2%
150-160	40,652	1%
160-170	38,259	1%
170-180	28,218	1%
180-190	28,604	1%
190-200	44,837	1%

Elev (m) Range	Count	Percent of Count
0-10	656,403	21%

Meters-to-Feet Cheat Sheet:

Meters	Feet
0	0
100	328
200	656
300	984
400	1312
500	1640
600	1969
700	2297
800	2625
900	2953
1000	3281
1100	3609
1200	3937
1300	4265
1400	4593
1500	4921
1600	5249
1700	5577
1800	5906
1900	6234
2000	6562
73	240
541	1775

Notes and Caveats for All Data:

1. Elevation data was from 30-meter DEMs. Elevations were analyzed in 100-meter increments, except elevations below 200 meters on the west side. The west side data below 200 meters were analyzed in 10-meter increments.

2. Land Use data came from EPA/USGS's NLCD Land Cover Classification System. The accuracy and currency of their data was not evaluated. The following categories were considered to be "Agriculture"

    61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

    81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

84. Fallow - Areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

Two other possible categories, "Grasslands/Herbaceous" and "Urban/Recreational Grasses," were not considered to be agriculture. While both of these categories include some agriculture, a large amount of the land in these categories would probably not be considered agricultural.

3. The accuracy of this elevation analysis was not determined. Therefore, outlier data should be treated cautiously. Specifically, the maximum elevation of agriculture (i.e. the counts at higher elevations) may be suspect. It is unknown if the very small percentages of agricultural practices at these elevations are real, or if they are some sort of data error.

Appendix C

Viruses and Parasites associated with Bacteria

Viruses

- The gastroenteritis viruses[48] are often called the "stomach flu," although it is not caused by the influenza viruses. The main symptoms of viral gastroenteritis are watery diarrhea and vomiting. The affected person may also have headache, fever, and abdominal cramps ("stomach ache"). In general, the symptoms begin 1 to 2 days following infection with a virus that causes gastroenteritis and may last for 1 to 10 days, depending on which virus causes the illness. The model assumes 4.35 restricted activity days involving loss of work days or school days for the flu like symptoms.[49] Many different viruses can cause gastroenteritis, including rotaviruses, adenoviruses, caliciviruses, astroviruses, Norwalk virus, and a group of Norwalk-like viruses. Rotavirus infection is the most common cause of diarrhea in infants and young children under 5 years old. Adenoviruses and astroviruses cause diarrhea mostly in young children, but older children and adults can also be affected. Norwalk and Norwalk-like viruses are more likely to cause diarrhea in older children and adults. Most people who get viral gastroenteritis recover completely without any long-term problems. Gastroenteritis is a serious illness, however, for persons who are unable to drink enough fluids to replace what they lose through vomiting or diarrhea. Infants, young children, and persons who are unable to care for themselves, such as the disabled or elderly, are at risk for dehydration from loss of fluids. Immune compromised persons are at risk for dehydration because they may get a more serious illness, with greater vomiting or diarrhea. They may need to be hospitalized for treatment to correct or prevent dehydration. Viral gastroenteritis is contagious. The viruses that cause gastroenteritis are spread through close contact with infected persons (for example, by sharing food, water, or eating utensils). Individuals may also become infected by eating or drinking contaminated foods or beverages. Food may be contaminated by food preparers or handlers who have viral gastroenteritis, especially if they do not wash their hands regularly after using the bathroom. This model does not extrapolate additional secondary exposures from the individuals exposed through water based recreation.

- Bacterial gastrointestinal illness may include abdominal cramps, nausea, bloating, urgency, bloody stool, fever, and/or malaise. Sixteen percent of the reportable waterborne disease outbreaks of gastroenteritis associated with recreational water were *E. coli* or shigella. The bacterial sources include Escherichia coli, Salmonella gastroenteritis, Shigellae, Campylobacter jejuni, Vibrio parahaemolyticus and less commonly Yersinia enterocolitica, Vibrio cholerae O1 and O139, non-O1 V. cholerae, Vibrio fluvialis, Aeromonas hydrophila and

[48] Most of the information in this bullet is copied directly from CDC data in the fact sheet at http://www.cdc.gov/ncidod/dvrd/revb/gastro/faq.htm.
[49] The number of days of illness is based on: Vital and Health Statistics: Current Estimates from the National Health Interview Survey, 1995, CDC Series 10 #199, Table 1, Table 16.

Plesiomonas shigelloides. Many of these are reportable infections and are not common here as they are in other parts of the world. If they are contracted here in the US, it is likely they were brought in from other countries. For example one of the more common reportable infections that can be acquired is Shigella. Shigella infections can also be acquired by swimming in contaminated water. Water may become contaminated if sewage runs into it, or if someone with shigellosis swims in it. About 18,000 cases of shigellosis are reported in the United States. Because many milder cases are not diagnosed or reported, the actual number of infections may be twenty times greater. Shigellosis is particularly common and causes recurrent problems in settings where hygiene is poor and can sometimes sweep through entire communities. Shigellosis is more common in summer than winter. Children, especially toddlers aged 2 to 4, are the most likely to get shigellosis. Persons with diarrhea usually recover completely, although it may be several months before their bowel habits are entirely normal. About 3% of persons who are infected with one type of Shigella, Shigella flexneri, will later develop pains in their joints, irritation of the eyes, and painful urination. This is called Reiter's syndrome. It can last for months or years, and can lead to chronic arthritis which is difficult to treat. Reiter's syndrome is caused by a reaction to Shigella infection that happens only in people who are genetically predisposed to it.[50] People may fight off the bacteria alone or they may require an antibiotic. A few will require other medical support.

Parasites

- Parasites, such as Giardia or amoeba may cause gastro enteritis like symptoms. Other common parasites cause rashes. Rare parasites such as Cryptosporidium parvum may cause more serious illness.
- Rashes[51] such as the common swimmers itch may appear within minutes to days after swimming in contaminated water, people may experience tingling, burning, or itching of the skin. Small reddish pimples appear within 12 hours. Pimples may develop into small blisters. Itching may last up to a week or more, but will gradually go away. The rash is caused by an allergic reaction to infection. Most cases do not require medical attention. Rashes can be treated with corticosteroid cream, cool compresses, bath with baking soda, baking soda paste to the rash, anti-itch lotion, Calamine lotion, colloidal oatmeal baths, and avoiding scratching. The model assumes 2.29 restricted activity days for rash related exposures.[52] The number of rashes is estimated based on a ratio of rashes to gastrointestinal outbreaks which were tracked by the CDC.

[50] Data is from the CDC fact sheet at: http://www.cdc.gov/ncidod/dbmd/diseaseinfo/shigellosis_g.htm#How do people catch Shigella.

[51] The information on rashes was taken from the CDC fact sheet at: http://www.cdc.gov/ncidod/dpd/parasites/schistosomiasis/factsht_cardmermatitis.htm. The numbers were extrapolated based on relative rates of reportable infection for nongastrointestinal and gastroenteritis water related exposures drawn from CDC data at: http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5108a1.htm.

[52] Vital and Health Statistics: Current Estimates from the National Health Interview Survey, 1995, CDC Series 10 #199, Table 1, Table 16.

Appendix C

SCORP data on visitor days.

Washington Citizens: Potential for recreational exposure to bacteria					
	Visitor Days*	Annual Participation Rate		Annual frequency	Share
Water: face exposure with bacterial content definite	**3,705,768**				
Fresh water: face exposure with bacterial content definite	**2,350,747**				
Swimming or wading at beach		9.55%		3.94	
Salt water	903,048				40%
Freshwater	1,354,572				60%
Surfboarding	81,120	0.20%		6.76	100%
Wind surfing		0.27%		3.26	
Salt water	11,091				21%
Freshwater	41,721				79%
Inner tubing and floating	405,408	2.06%		3.28	100%
White water rafting	61,404	0.43%		2.38	100%
Personal Watercraft - jet ski		1.41%		2.94	
Salt water	22,385				9%
Freshwater	226,339				91%
Water skiing		2.22%		3.50	
Salt water	130,536				28%
Freshwater	335,664				72%
Scuba and skin diving		0.80%		2.76	
Salt water	68,890				52%
Freshwater	63,590				48%
Water: face exposure with bacterial content possible	**8,751,995**				
Fresh Water: face exposure with bacterial content possible	6,107,028				
Fishing from a bank or dock		7.86%		4.12	
Salt water	291,449				15%
Freshwater	1,651,543				85%
Fishing from a private boat		7.73%		3.58	
Salt water	398,497				24%
Freshwater	1,261,907				76%
Fishing with a guide or charter		0.71%		2.25	
Salt water	78,597				82%
Freshwater	17,253				18%
Beach combing	1,173,378	7.27%		2.69	100%
Hand powered -canoe, kayak, rowboat		2.97%		3.78	
Salt water	168,399				25%
Freshwater	505,197				75%
Sail boating		0.83%		3.13	
Salt water	48,321				31%
Freshwater	107,553				69%
Motor boating		7.84%		3.61	
Salt water	441,517				26%
Freshwater	1,256,627				74%
Observing photographing: Marine whales dolphins etc.	829,709	42.16%		6.56	5%
Camping with kayak or canoe	105,996	0.73%		2.42	100%
Camping on a boat	416,052	1.27%		5.46	100%